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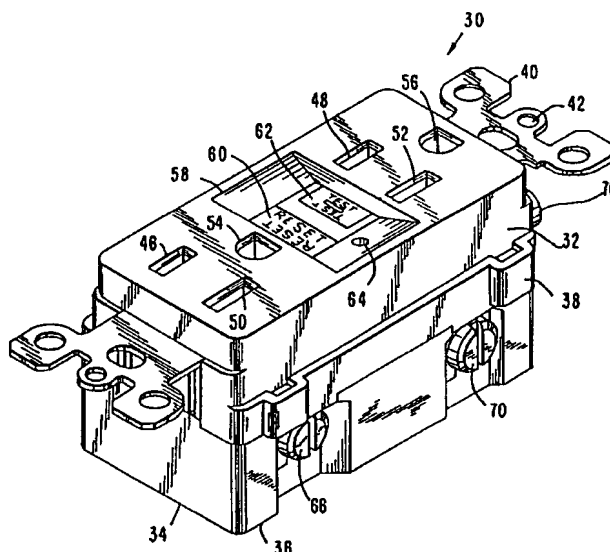
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(54) Title: CIRCUIT INTERRUPTING DEVICE



(57) Abstract: Resettable circuit interrupting devices, such as GFCI devices (ground fault circuit interrupters), ALCI devices (arc fault circuit interrupters), ICDI devices (immersion detection circuit interrupters), RCDs (residual current devices), that include reverse wiring protection (fig. 62), and optionally an independent trip portions (fig. 24) and/or a reset lockout portion (60, 330) are provided. Further is a signaling system employing indicator lamp means (64) and an audible alarm (236) is employed to remind a user to periodically test his GFCIs and to provide information regarding the status of the GFCI. The power lines that supply the GFCI with power are also coupled to the circuits on the PCB (122) to disconnect power to those circuits of the GFCI that trips due to faults or tests.



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CIRCUIT INTERRUPTING DEVICE**CLAIM OF PRIORITY**

The applicants hereby claim priority for this application to the following pending
5 and commonly owned applications filed in the United States Patent Office (USPTO):

Application having Serial No. 09/812,875, attorney docket no. 0267-1415CIP8
(41912.018100) and entitled "Reset Lockout For Sliding Latch GFCI" by inventors Frantz
Germain, Stephen Stewart, David Herzfeld, Steven Campolo, Nicholas DiSalvo and
10 William R. Ziegler, filed on March 20, 2001.

Application having Serial No. 09/812,288, attorney docket no. 0267-1415CIP9
(41912.015600) and entitled "Circuit Interrupting Device With Reset Lockout and Reverse
Wiring Protection and Method of Manufacture" by inventors Steven Campolo, Nicholas
15 DiSalvo and William R. Ziegler, filed on March 20, 2001.

Application having Serial No. 09/813,412, attorney docket no. 0267-1415CIP6
(41912.017400) and entitled "Pivot Point Reset Lockout Mechanism For A Ground Fault
Circuit Interrupter" by inventors Frantz Germain, Stephen Stewart, Roger Bradley,
20 Nicholas L. DiSalvo and William R. Ziegler, filed on March 21, 2001.

Application having Serial No. 60/277,448, attorney docket no. 0267-1596 (41912.017700)
and entitled "GFCI With Reset Lockout" by inventor Richard Bernstein, filed on March
21, 2001.
25

Application having Serial No. 09/813,683, attorney docket no. 0267-1415CIP4
(41912.017500) and entitled "IDCI With Reset Lockout And Independent Trip" by
inventor Nicholas DiSalvo, filed on March 21, 2001.

Application having Serial No. 60/277,446, attorney docket no. 0267-1415CIP7
(41912.017400) and entitled "ALCI With Reset Lockout and Independent Trip" by
inventors Richard Ulrich, William R. Ziegler, Nicholas L. DiSalvo, Frantz Germain, filed
5 on March 21, 2001.

Application having Serial No. 60/277,097, attorney docket no. 0267-1904 (41912.018200)
and entitled "Lockout Mechanism For Residual Current Devices" by inventors Frantz
Germain, Stephen Stewart, Armando Calixto, and Steve Campolo, filed on March 19,
10 2001.

Application having Serial No. 09/812,601, attorney docket no. 0267-1689 (41912.017900)
and entitled "Neutral Switch Test Mechanism For A Circuit Interrupter" by inventors
David Y. Chan, James Richter, and Gerald N. King, filed on March 20, 2001.

15 Application having Serial No. 09/812,624, attorney docket no. 0267-1415CIP5
(41912.017300) and entitled "Reset Lockout Mechanism And Independent Trip Mechanism
For Center Latch Circuit Interrupting Device" by inventors Frantz Germain, Steven
Stewart, Roger Bradley, David Chan, Nicholas L. DiSalvo and William R. Ziegler, filed
20 on March 20, 2001.

Application having Serial No. 09/829,339, attorney docket no. 0267-1430 (41912.018500)
and entitled "Circuit Interrupter With Improved Surge Suppression" by inventors David Y.
Chan, Eugene Shafir, filed on April 9, 2001.

25 Application having Serial No. 09/688,481, attorney docket no. 0267-001-1369 and entitled
"Ground Fault Circuit Interrupter" by inventor David Herzfeld, filed on October 16, 2001.

CROSS REFERENCE TO RELATED APPLICATIONS

This application is related to a commonly owned application Serial No. 09/812,875, filed March 20, 2001, entitled Reset Lockout For Sliding Latch GFCI, by inventors Frantz Germain, Stephen Stewart, David Herzfeld, Steven Campolo, Nicholas DiSalvo and
5 William R. Ziegler, having attorney docket 0267-1415CIP8 (41912.018100), which is a continuation-in-part of application Serial No. 09/688,481 filed October 16, 2000, which is incorporated herein in its entirety by reference.

This application is related to commonly owned application Serial No. 09/812,288, filed March 20, 2001, entitled Circuit Interrupting Device with Reset Lockout and Reverse
10 Wiring Protection and Method of Manufacture, by inventors Steven Campolo, Nicholas DiSalvo and William R. Ziegler, having attorney docket 0267-1415CIP9(41912.015600), which is a continuation-in-part of application Serial No. 09/379,138 filed August 20, 1999, which is a continuation-in-part of application Serial No. 09/369,759 filed August 6, 1999, which is a continuation-in-part of application Serial No. 09/138,955, filed August 24,
15 1998, now U.S. Patent No. 6,040,967, all of which are incorporated herein in their entirety by reference.

This application is related to commonly owned application Serial No. 09/812,624, filed March 20, 2001, entitled Reset Lockout Mechanism and Independent Trip Mechanism for Center Latch Circuit Interrupting Device, by inventors Frantz Germain, Steven
20 Stewart, Roger Bradley, David Chan, Nicholas L. DiSalvo and William R. Ziegler, having attorney docket 0267-1415CIP5(41912.017300), herein incorporated by reference.

This application is related to commonly owned application Serial No. 09/379,140 filed August 20, 1999, which is a continuation-in-part of application Serial No. 09/369,759 filed August 6, 1999, which is a continuation-in-part of application Serial No. 09/138,955,
25 filed August 24, 1998, now U.S. Patent No. 6,040,967, all of which are incorporated herein in their entirety by reference.

This application is related to commonly owned application Serial No. 09/813,683, filed March 21, 2001, entitled IDCI With Reset Lockout and Independent Trip, by inventor Nicholas DiSalvo, having attorney docket 0267-1415CIP4 (41912.017500) which is
30 incorporated herein in its entirety by reference.

This application is related to commonly owned application Serial No. 09/813,412, filed March 21, 2001, entitled Pivot Point Reset Lockout Mechanism For A Ground Fault Circuit Interrupter, by inventors Frantz Germain, Stephen Stewart, Roger Bradley, Nicholas L. DiSalvo and William R. Ziegler, having attorney docket 0267-1415CIP6
5 (41912.017400), herein incorporated by reference.

BACKGROUND

1. Field

The present invention is directed to resettable circuit interrupting devices including without limitation ground fault circuit interrupters (GFCI's), arc fault circuit interrupters
10 (AFCI's), immersion detection circuit interrupters (IDCI's), appliance leakage circuit interrupters (ALCI's), equipment leakage circuit interrupters (ELCI's), circuit breakers, contactors, latching relays and solenoid mechanisms.

Certain embodiments of the present invention are directed to circuit interrupting devices including a reset lock out portion capable of preventing the device from resetting in
15 certain circumstances.

Certain embodiments of the present invention are directed to circuit interrupting devices that include a circuit interrupting portion that can break electrically conductive paths between a line side and a load side of the device and between a line side and a user load. Certain embodiments of the present application are directed to circuit interrupting
20 devices including a reset lock out portion capable of preventing the device from resetting if the circuit interrupting portion is not functioning, if an open neutral condition exists or if the device is mis-wired. Certain embodiments of the present application are directed to methods of manufacturing circuit interrupting devices to be initially in a tripped condition. Certain embodiments of the present application are directed to methods of manufacturing
25 circuit interrupting devices to be initially in a reset lock out condition.

Certain embodiments of the present invention are also directed to circuit interrupting devices that include a circuit interrupting portion that can isolate a power source connector from a load connector.

Certain embodiments of the present invention is directed to resettable circuit interrupting devices including without limitation GFCIs. Certain embodiments of the present invention are directed to circuit interrupting devices using a neutral fault simulation. Certain embodiments of the present application are directed to circuit interrupting devices including a neutral to neutral test switch.

Certain embodiments of the present invention relate to surge suppression, and in particular to circuit interrupters and GFCIs and related products with enhanced transient suppression and protection characteristics.

Certain embodiments of the present invention are directed to GFCIs that include a reset lock out portion that does not fire the solenoid for test

Certain embodiments of the present invention are directed to IDCIs that include a reset lock portion capable of preventing the device from resetting under certain circumstances and an independent trip mechanism.

Certain embodiments of the present invention are directed to ALCIs and IDCIs that include a reset lock out portion capable of preventing the device from resetting under certain circumstances.

Certain embodiments of the present application are also directed to resettable residual current devices (RCDs). More particularly, the present application is directed to a RCE that can lockout the reset function if a predetermined condition exists.

Other embodiments of the present invention pertain to ground fault circuit interrupters and more particularly to a GFCI which employs a combination of colored lights and an audible alarm signal to shown various states of the GFCI and designate time periods for taking certain actions.

2. Description of the Related Art

25 I. Inoperative Trip Mechanism

Many electrical wiring devices have a line side, which is connectable to an electrical power supply, and a load side, which is connectable to one or more loads and at least one conductive path between the line and load sides. Electrical connections to wires supplying electrical power or wires conducting electricity to the one or more loads are at line side and

load side connections. The electrical wiring device industry has witnessed an increasing call for circuit breaking devices or systems which are designed to interrupt power to various loads, such as household appliances, consumer electrical products and branch circuits. Many electrical appliances have an electrical cord having a line side, which is connectable to an electrical power supply, and a load side that is connected to the appliance, which is an electrical load. Certain appliances may be susceptible to immersion in a conductive fluid, which may present a shock hazard. Other fault scenarios may be addressed by other circuit interrupters alone or in combination. Accordingly, the electrical wiring device industry has witnessed an increasing call for circuit breaking devices or systems which are designed to interrupt power to various loads, such as household appliances, consumer electrical products and branch circuits. In particular, appliances utilized in areas that may be wet, such as hair dryers, may be equipped with an IDCI to protect against immersion hazards. Such products have been marketed by companies under brand names including Conair, Windmere and Wellong. In particular, electrical codes require electrical circuits in home bathrooms and kitchens to be equipped with ground fault circuit interrupters (GFCI), for example. Presently available GFCI devices, such as the device described in commonly owned U.S. Patent 4,595,894, use an electrically activated trip mechanism to mechanically break an electrical connection between the line side and the load side of a GFCI. Such devices are resettable after they are tripped by, for example, the detection of a ground fault. In the device discussed in the '894 patent, the trip mechanism used to cause the mechanical breaking of the circuit (i.e., the conductive path between the line and load sides) includes a solenoid (or trip coil). A test button is used to test the trip mechanism and circuitry used to sense faults, and a reset button is used to reset the electrical connection between line and load sides.

However, instances may arise where an abnormal condition, caused by for example a lightning strike, occurs which may result not only in a surge of electricity at the device and a tripping of the device but also a disabling of the trip mechanism used to cause the mechanical breaking of the circuit. This may occur without the knowledge of the user. Under such circumstances an unknowing user, faced with a GFCI which has tripped, may press the reset button which, in turn, will cause the device with an inoperative trip

mechanism to be reset without the ground fault protection available. The GFCI will be in a dangerous condition because it will then provide power to a load without ground fault protection.

Further, an open neutral condition, which is defined in Underwriters Laboratories (UL) Standard PAG 943A, may exist with the electrical wires supplying electrical power to such GFCI devices. If an open neutral condition exists with the neutral wire on the line (versus load) side of the GFCI device, an instance may arise where a current path is created from the phase (or hot) wire supplying power to the GFCI device through the load side of the device and a person to ground. In the event that an open neutral condition exists, current GFCI devices, which have tripped, may be reset even though the open neutral condition may remain.

Commonly owned application Serial No. 09/138,955, filed August 24, 1998, now U.S. Patent No. 6,040,967, which is incorporated herein in its entirety by reference, describes a family of resettable circuit interrupting devices capable of locking out the reset portion of the device if certain conditions exist including the circuit interrupting portion being non-operational or if an open neutral condition exists. Such a device may use a simulated ground fault to initiate a device test. Accordingly, it may be advantageous to lockout the reset function under certain circumstances.

II. The Problem of Mis-wiring

Some of the circuit interrupting devices described above also have a user accessible load connection. The user accessible load side connection includes one or more connection points where a user can externally connect to electrical power supplied from the line side. The load side connection and user accessible load connection are typically electrically connected together. An example of such a circuit interrupting device is a typical GFCI receptacle, where the line and load side connections are binding screws and the user accessible load side connection is the plug connection to an internal receptacle. As noted, such devices are connected to external wiring so that line wires are connected to the line side connection and load side wires are connected to the load side connection. However, instances may occur where the circuit interrupting device is improperly connected to the

external wires so that the load wires are connected to the line side connection and the line wires are connected to the load connection. This is known as reverse wiring. In the event the circuit interrupting device is reverse wired, fault protection to the user accessible load connection may be eliminated, even if fault protection to the load side connection remains.

5 Furthermore, studies related to GFCI devices indicate that perhaps 10-20% or more of all GFCI devices installed were found to be inoperable by the user. However, after those devices were returned to the manufacturer, most were found to be operational. Accordingly, it has been suggested that the devices were reverse wired by the user (line – load side reversal). Furthermore, regulatory codes and industry standards codes such as
10 those by Underwriters Laboratories (UL) may require that GFCI devices be manufactured with a warning label advising the user to correctly wire the line and load terminals of the device. However, even such warnings may not be adequate as suggested by the studies above. Furthermore, a reasonably foolproof mis-wiring prevention scheme may obviate the need for such a warning label.

15 Conventional GFCI devices may utilize a user load such as a face receptacle. Typically GFCIs are four terminal devices, two phase or AC leads for connection to AC electrical power and two LOAD leads for connection to downstream devices. If a conventional GFCI is properly wired, the GFCI provides ground fault protection for devices downstream and the incorporated receptacle. However, if a conventional GFCI is
20 reverse wired, unprotected power is provided to the receptacle face at all times. For example, when a conventional GFCI is reverse wired, the face receptacle is “upstream” from the current imbalance sensor coil. Accordingly, if the conventional GFCI is in either the tripped or normal state, the face receptacle is provided unprotected power.

 In spite of detailed instructions that come packaged with most GFCIs and
25 identification of AC and LOAD terminals, GFCIs are sometimes mis-wired. One reason that this problem exists is that in new construction, both the input line and downstream cables appear identical when the installer is connecting a new ground fault circuit interrupter. This is especially a problem in new construction where there is no power available in order to test which cable is leading current into the device.

The problem may be compounded when it is considered that many typical duplex receptacle GFCIs have a test button that will trip and shut off the power when pushed to verify operations of internal functions in the GFCI. However, use of the test button does not indicate whether the built in duplex receptacle is protected. Typical users may not be aware of this. Users simply test the device after installation and verify that the unit trips upon pressing the test button by way of an audible click, for example. This gives the user a false sense that all is well. What is actually happening when the GFCI is reverse wired is that the GFCI disconnects power from and protects everything downstream, but does not protect the receptacle contacts of the GFCI itself. The device will trip depending on the condition of internal components and irrespective of how the GFCI was wired. It does not matter that the GFCI was reverse wired when it was tested.

Certain references described devices that attempt to warn the user of a reverse wiring condition. For example, one approach utilizes a GFCI with reverse line polarity lamp indicator to indicate proper installation of the GFCI. See, for example, U.S. Patent No. 4,412,193 issued to Bienwald et al. on October 25, 1983 and assigned to the owner of the present invention. However, a push button needs to be manually pressed in accordance with instructions in order to detect whether the GFCI is mis-wired.

In another example, U.S. Patent No. 5,477,412 issued to Neiger et al. on December 19, 1995 and owned by the assignee of the present invention, is directed to a ground fault circuit interrupter incorporating mis-wiring prevention circuitry. Mis-wiring sense circuitry automatically triggers the generation of visual and audible alarms in the event of mis-wiring conditions. The circuit employs an alarm inhibiting technique that incorporates sense circuitry connected to the AC terminals on one side of the internal GFCI switches or relays and alarm generation circuitry connected to the load terminal on the opposite side.

Commonly owned application Serial No. application Serial No. 09/204,861, filed December 3, 1998, which is incorporated herein in its entirety by reference, describes a device to test for reverse wiring and provide an indication of reverse wiring.

The applications referenced above as related applications are commonly owned and incorporated herein by reference. The applications generally relate to locking out a rest

function or otherwise disabling a circuit interrupting device on the occurrence of a condition.

United States Patent No. 5,933,063 to Keung, et al., purports to describe a GFCI device and apparently utilizes a single center latch. U. S. Patent No. 5,933,063 is hereby
5 in its entirety be reference. United States Patent No. 5,594,398 to Marcou, et al., purports to describe a GFCI device and apparently utilizes a center latch. U. S. Patent No. 5,594,398 is hereby in its entirety be reference. United States Patent No. 5,510,760 to Marcou, et al., purports to describe a GFCI device and apparently utilizes a center latch. U. S. Patent No. 5,594,398 is hereby in its entirety be reference. A typical GFCI design
10 that may benefit from a modification according to the present invention has been marketed under the designation Pass & Seymour Catalog No. 1591.

Another GFCI design that may benefit from a modification according to the present invention has been marketed under the designation Bryant Catalog Number GFR52FTW.

Commonly owned application Serial No. No. 09/379,138 filed August 20, 1999,
15 which is incorporated herein in its entirety by reference, describes a family of resettable circuit interrupting devices capable of independently tripping and protecting against reverse wiring.

III. Inadequate Surge Protection

Known GFCI products typically include a metal oxide varistor (MOV) positioned
20 across the power lines of the GFCI product, with the MOV providing some surge protection to the GFCI product circuitry by clamping transient voltages to acceptable levels. The degree of clamping is determined by the size of the disc and voltage rating associated with the MOV. Heretofore, GFCI products have been limited to handling transient voltages of 6 kV at 100 A. A need exists for GFCI products capable of sustaining
25 greater transient conditions.

In addition, due to deregulation of local power authorities, overvoltage conditions may be more prevalent, requiring circuits to survive, for example, 240 V overvoltage conditions for a 120 V rated product. When such conditions occur, GFCI components such as the MOV in the prior art have not survived; for example, a MOV in the prior art

operating beyond its rating at overvoltage may disintegrate, and thus such conditions may also destroy the rest of the electronics in the GFCI product.

A need exists for a surge protection circuit which allows components such as a MOV to survive power conditions exceed voltage and current ratings, and thus enabling a
5 GFCI product to survive overvoltage conditions.

IV. Lack of Status Indication

As discussed above, there are various circumstances which may cause a circuit interrupting device to malfunction. Present GFCI's generally provide no information to the user as to the status of the GFCI. One GFCI currently on sale provides a single LED to
10 show that the device is operating, that is the main switch contacts are closed. Therefore, there is a need for a user to be able to determine whether a circuit interrupting device is malfunctioning by obtaining the status of such a device.

SUMMARY

The present application relates to a resettable circuit interrupting devices that
15 provide a reset lockout under certain conditions. Certain embodiments of the present application are directed to circuit interrupting devices including a reset lock out portion capable of preventing the device from resetting if the circuit interrupting portion is not functioning, if an open neutral condition exists or if the device is mis-wired by testing portions of a device before allowing a reset. Certain embodiments maintain fault
20 protection for the circuit interrupting device even if the device is reverse wired by utilizing a bridge circuit to separately break the line inputs from each respective load side connector and user load connector.

The circuit interrupting device may also include reset lockout portion that prevents the reestablishing of electrical continuity in either the phase or neutral conductive path or
25 both conductive paths, unless the circuit interrupting portion is operating properly and/or connected properly. In certain embodiments, the reset portion may be configured so that at least one reset contact is electrically connected to the sensing portion of the circuit interrupting portion, and that depression of a reset button causes at least a portion of the phase conductive path to contact at least one reset contact. When contact is made between

the phase conductive path and the at least one reset contact, the circuit interrupting portion is activated so that the reset lockout portion is disabled and electrical continuity in the phase and neutral conductive paths can be reestablished.

The circuit interrupting device may also include a trip portion that operates
5 independently of the circuit interrupting portion. In one embodiment, the trip portion includes a trip actuator accessible from an exterior of the housing and a trip arm preferably within the housing and extending from the trip actuator. The trip arm is preferably configured to facilitate mechanical breaking of electrical continuity in the phase and/or neutral conductive paths, if the trip actuator is actuated.

10 In certain embodiments, the circuit interrupter is manufactured having a bridge circuit separately disconnecting a load side and a user load when the circuit interrupter trips. In another embodiment, two single-pole, single throw switching devices are used to switch each power line from the load and the user load respectively. In another embodiment, the circuit interrupter is manufactured in a reset lock out state. In another
15 embodiment, a removable or fixedly connected trip force device is utilized to force a trip upon installation. In another embodiment, an indicator provides an indication of reverse wiring. In another embodiment, a separate trip force device is connected to the circuit interrupter before it is delivered into the stream of commerce. In a method embodiment, the circuit interrupter is set to a reset lock out state before being delivered into the stream
20 of commerce.

The present invention also relates to a resettable circuit interrupting devices that maintain fault protection for the circuit interrupting device even if the device is reverse wired.

In one embodiment, the circuit interrupting device includes a housing and phase and
25 neutral conductive paths disposed at least partially within the housing between line and load sides. Preferably, the phase conductive path terminates at a first connection capable of being electrically connected to a source of electricity, a second connection capable of conducting electricity to at least one load and a third connection capable of conducting electricity to at least one user accessible load. Similarly, the neutral conductive path,
30 preferably, terminates at a first connection capable of being electrically connected to a

source of electricity, a second connection capable of providing a neutral connection to the at least one load and a third connection capable of providing a neutral connection to the at least one user accessible load;

5 The circuit interrupting device also includes a circuit interrupting portion that is disposed within the housing and configured to cause electrical discontinuity in one or both of the phase and neutral conductive paths, between said line side and said load side upon the occurrence of a predetermined condition. A reset portion is disposed at least partially within the housing and is configured to reestablish electrical continuity in the open conductive paths.

10 Preferably, the phase conductive path includes a plurality of contacts that are capable of opening to cause electrical discontinuity in the phase conductive path and closing to reestablish electrical continuity in the phase conductive path, between said line and load sides. The neutral conductive path also includes a plurality of contacts that are capable of opening to cause electrical discontinuity in the neutral conductive path and closing to
15 reestablish electrical continuity in the neutral conductive path, between said line and load sides. In this configuration, the circuit interrupting portion causes the plurality of contacts of the phase and neutral conductive paths to open, and the reset portion causes the plurality of contacts of the phase and neutral conductive paths to close.

One embodiment for the circuit interrupting portion uses an electro-mechanical
20 circuit interrupter to cause electrical discontinuity in the phase and neutral conductive paths, and sensing circuitry to sense the occurrence of the predetermined condition. For example, the electro-mechanical circuit interrupter include a coil assembly, a movable plunger attached to the coil assembly and a banger attached to the plunger. The movable plunger is responsive to energizing of the coil assembly, and movement of the plunger is
25 translated to movement of said banger. Movement of the banger causes the electrical discontinuity in the phase and/or neutral conductive paths.

The circuit interrupting device may also include reset lockout portion that prevents the reestablishing of electrical continuity in either the phase or neutral conductive path or both conductive paths, unless the circuit interrupting portion is operating properly. That
30 is, the reset lockout prevents resetting of the device unless the circuit interrupting portion is

operating properly. In embodiments where the circuit interrupting device includes a reset
lockout portion, the reset portion may be configured so that at least one reset contact is
electrically connected to the sensing circuitry of the circuit interrupting portion, and that
depression of a reset button causes at least a portion of the phase conductive path to contact
5 at least one reset contact. When contact is made between the phase conductive path and the
at least one reset contact, the circuit interrupting portion is activated so that the reset
lockout portion is disabled and electrical continuity in the phase and neutral conductive
paths can be reestablished.

The circuit interrupting device may also include a trip portion that operates
10 independently of the circuit interrupting portion. The trip portion is disposed at least
partially within the housing and is configured to cause electrical discontinuity in the phase
and/or neutral conductive paths independent of the operation of the circuit interrupting
portion. In one embodiment, the trip portion includes a trip actuator accessible from an
exterior of the housing and a trip arm preferably within the housing and extending from the
15 trip actuator. The trip arm is preferably configured to facilitate mechanical breaking of
electrical continuity in the phase and/or neutral conductive paths, if the trip actuator is
actuated. Preferably, the trip actuator is a button. However, other known actuators are
also contemplated.

In an embodiment, the circuit interrupter is manufactured having a bridge circuit separately
20 disconnecting a load side and a user load when the circuit interrupter trips. In another
embodiment, two single-pole, single throw switching devices are used to switch each
power line from the load and the user load respectively. In another embodiment, the
circuit interrupter is manufactured in a reset lock out state. In another embodiment, a
removable or fixedly connected trip force device is utilized to force a trip upon installation.
25 In another embodiment, an indicator provides an indication of reverse wiring. In another
embodiment, a separate trip force device is connected to the circuit interrupter before it is
delivered into the stream of commerce. In a method embodiment, the circuit interrupter is
set to a reset lock out state before being delivered into the stream of commerce.

The present invention also relates to a resettable circuit interrupting devices having
30 a reset lockout that does not rely on a test of the solenoid.

The present invention also relates to resettable circuit interrupting devices that include a user interface. Before the device is used, it is tripped. The user must then use the user interface to enable a test actuator to initiate a test the device. If the test passes, the device will reset. Otherwise, the device will be locked out. In another embodiment, the
5 device may be tripped by a user interface to a mechanical trip mechanism.

One embodiment for the circuit interrupting portion uses an electro-mechanical circuit interrupter to cause electrical discontinuity in at least one of the phase and neutral conductive paths of the device, and sensing circuitry to sense the occurrence of a predetermined condition. The mechanical trip arm may be configured to facilitate
10 mechanical breaking of electrical continuity in the phase and/or neutral conductive paths, if the trip actuator is actuated. Furthermore, the mechanical trip arm or level may be configured so that it will not be operable to reset the device.

The present invention also relates to a resettable RCD that may be locked out from reset. A user actuated reset lever moves from an off state to an on state through a test
15 state. The test state will test the device and only allow progression to the on state if the test passes.

The present invention also relates to a resettable circuit interrupting devices that simulate a fault condition by simulating a neutral fault condition. The neutral fault may be simulated by connecting a load neutral line to a line neutral line using a switch to create a
20 feedback path in the sensor that will trigger the circuit interrupter.

Furthermore, the neutral fault may be simulated using a third wire through the transformer or by connecting a load phase line to a line phase line.

The fault switch is preferably configured to facilitate mechanical connection between the line and load neutral paths. However, other known actuators are also contemplated.

25 The present invention also relates to a resettable circuit interrupting devices that lockout the reset function under certain conditions. In one embodiment, a test mechanism is utilized to test the circuit interrupter before allowing a reset. In an embodiment, a reset plunger is modified to exert force on a trip latch in order to close a test circuit that will allow the reset plunger to continue to a reset position only if the circuit interrupter is
30 functioning.

The present invention also relates to a suppression and protection circuit used in conjunction with a metal oxide varistor (MOV) in a ground fault circuit interrupter (GFCI) product for handling transient surges and overvoltage conditions. The suppression and protection circuit includes a spark gap to prevent overvoltages, and an LC low pass filter
5 for suppressing transient surges.

The present invention also provides a GFCI that gives the user a great deal of information on the status of the GFCI and the circuit it is to protect. The GFCI includes a dual color lamp which can produce three distinct colors. Further, the lamp is intended to be blinked at a first slow rate or a second higher rate. An audible alarm can be operated or
10 maintained silent. The information given the user will depend upon the color of the lamp, the speed at which it is blinked and the presence or absence of an audible alarm signal. It is an object of the instant invention to provide a novel GFCI.

It is another object of the instant invention to provide a novel GFCI with signaling means to show the status of the GFCI and associated circuits.

15 It is another object of the instant invention to provide a novel GFCI with signaling means comprising blinking colored lights and an audible alarm to show the status of the GFCI and associated circuits.

Other objects and features of the invention will be pointed out in the following description and claims and illustrated in the accompanying drawings, which disclose, by
20 way of example, the principles of the invention, and the best mode which is presently contemplated for carrying them out.

BRIEF DESCRIPTION OF THE DRAWINGS

Preferred embodiments of the present application are described herein with reference to the drawings in which similar elements are given similar reference characters,
25 wherein:

FIGS. 1-41 show a sliding latch GFCI with reset lockout and in particular:

FIG. 1 is a perspective view of a GFCI constructed in accordance with the concepts of the invention;

FIG. 2 is a bottom perspective view of the GFCI of FIG. 1;

FIG. 3 is similar to FIG. 1 but with the top and bottom covers of the GFCI removed;

FIG. 4 is a perspective view of the mounting strap of the device of FIG. 1;

FIG. 5 is a bottom perspective view of the load neutral and load phase terminals of the device of FIG. 1;

FIG. 6 is a perspective view of the printed circuit board and reset assemblies of the device of FIG. 1;

FIG. 7 is a perspective view of the devices of FIG. 6 with the reset lever and PC board removed;

FIG. 8 is a perspective view of the bobbin assembly of the device of FIG. 1;

FIG. 9 is a perspective view of the main movable contacts of the device of FIG. 1;

FIG. 10 is a bottom perspective view of the plunger, latch plate and auxiliary contacts of the device of FIG. 1;

FIG. 11 is a perspective view showing the transformers mounted on the printed circuit board of the device of FIG. 1;

FIG. 12 is a side elevational view partly in section of the transformer bracket assembly of FIG. 11;

FIG. 13 is a perspective view of the test lever and button of the device of FIG. 1;

FIG. 14 is front elevational view of the test lever, test button, test arm and test pin in the open position;

FIG. 15 is a front elevational view of the components shown in FIG. 14 in the closed, test position;

FIG. 16 is a perspective view of the reset lever and reset button of the device of FIG. 1;

FIG. 17 is a front elevational view of the reset lever reset button, main contacts and auxiliary contacts in the closed or reset condition;

FIG. 18 is a side elevational view of the device according to FIG. 17;

FIG. 19 is a front elevational view of the components of FIG. 17 in the tripped condition;

FIG. 20 is a side elevational view of the device of FIG. 19;

FIG. 21 is a table to show the relationships between the status of the GFCI and associated circuits and the color, speed of blinking and the presence or absence of an audible signal;

FIG. 22 is a schematic diagrams of a GFCI according to an embodiment of the
5 present invention;

FIG. 23 is a schematic diagrams of a GFCI according to an embodiment of the present invention having a bridge circuit;

FIG. 24 is a schematic diagrams of a GFCI according to an embodiment of the present invention having a bridge circuit an independent trip mechanism;

10 FIGS. 25-28b are partial cutaway diagrams of the reset lockout mechanism of a GFCI according to an embodiment of the present invention;

FIGS. 29a-c are partial cutaway diagrams of the reset lockout mechanism of a GFCI according to another embodiment of the present invention;

15 FIG. 30 is a partial cutaway diagram of the reset lockout mechanism of a GFCI according to the embodiment of FIG. 29a-c showing a manual trip mechanism;

FIGS. 31a-f are partial cutaway diagrams of the reset lockout mechanism of a GFCI according to the embodiment of FIG. 29a-c showing a manual trip mechanism;

FIGS. 32a-b are partial cutaway diagrams of the reset lockout mechanism of a GFCI according to another embodiment of the present invention;

20 FIGS. 33a-f are partial cutaway diagrams of the reset lockout mechanism of a GFCI according to another embodiment of the present invention;

FIGS. 34a-f are partial cutaway diagrams of the reset lockout button of a GFCI according to two embodiments of the present invention;

25 FIG. 35 is a perspective view of one embodiment of a ground fault circuit interrupting device according to the present application having a user load activated switch;

FIGS. 36a-b are perspective views of one embodiment of a ground fault circuit interrupting device according to the present application having a user load activated switch device;

30 FIG. 37 is a perspective view of one embodiment of a ground fault circuit interrupting device according to the present application having a user load activated switch;

FIGS. 38a-c are perspective views of one embodiment of a ground fault circuit interrupting device according to the present application having a user load activated switch device;

FIG. 39 is a perspective views of one embodiment of a ground fault circuit interrupting device according to the present application having a user load activated switch devices for trip and reset activation without user buttons; and

FIG. 40 is a perspective view of one embodiment of a ground fault circuit interrupting device according to the present application having a user load activated switch device and no buttons;

FIG. 41 is a perspective views of one embodiment of a ground fault circuit interrupting device according to the present application having a movable face plate and face plate movement activated switch devices for trip and reset activation without user buttons.

FIGS. 42-70 show a circuit interrupting device with reset lockout and reverse wiring protection and method of manufacture such a device wherein:

FIG. 42 is a perspective view of one embodiment of a ground fault circuit interrupting device according to the present application;

FIG. 43 is side elevational view, partly in section, of a portion of the GFCI device shown in FIG. 42, illustrating the GFCI device in a set or circuit making position;

FIG. 44 is an exploded view of internal components of the circuit interrupting device of FIG. 42;

FIG. 45 is a plan view of portions of electrical conductive paths located within the GFCI device of FIG. 42;

FIG. 46 is a partial sectional view of a portion of a conductive path shown in FIG. 4;

FIG. 47 is a partial sectional view of a portion of a conductive path shown in FIG. 4;

FIG. 48 is a side elevational view similar to FIG. 2, illustrating the GFCI device in a circuit breaking or interrupting position;

FIG. 49 is a side elevational view similar to FIG. 2, illustrating the components of the GFCI device during a reset operation;

FIGS. 50-52 are schematic representations of the operation of one embodiment of the reset portion of the present application, illustrating a latching member used to make an electrical connection between line and load connections and to relate the reset portion of the electrical connection with the operation of the circuit interrupting portion;

5 FIG. 53 is a schematic diagram of a circuit for detecting ground faults and resetting the GFCI device of FIG. 1;

FIG. 54 is a perspective view of an alternative embodiment of a ground fault circuit interrupting device according to the present application;

FIG. 55 is side elevational view, partly in section, of a portion of the GFCI device
10 shown in FIG. 54, illustrating the GFCI device in a set or circuit making position;

FIG. 56 is a side elevational view similar to FIG. 55, illustrating the GFCI device in a circuit breaking position;

FIG. 57 is a side elevational view similar to FIG. 14, illustrating the components of the GFCI device during a reset operation;

15 FIG. 58 is an exploded view of internal components of the GFCI device of FIG. 13;

FIG. 59 is a schematic diagram of a circuit for detecting ground faults and resetting the GFCI device of FIG. 54;

FIG. 60 is side elevational view, partly in section, of components of a portion of the alternative embodiment of the GFCI device shown in FIG. 54, illustrating the device in a
20 set or circuit making position;

FIG. 61 is a side elevational view similar to FIG. 60, illustrating of the device in a circuit breaking position;

FIG. 62 is a block diagram of a circuit interrupting system according to the present application;

25 FIGS. 63a-b are partial schematic diagrams of a conventional GFCI properly wired in FIG. 63a and reverse wired in FIG. 63b;

FIGS. 64a-b are partial schematic diagrams of a GFCI according to an embodiment of the present invention properly wired in FIG. 64a and reverse wired in FIG. 64b;

FIGS. 65a-b are partial schematic diagrams of a GFCI according to an another embodiment of the present invention having a reset lock out shown properly wired in FIG. 65a and reverse wired in FIG. 65b;

FIG. 66a is a partial schematic diagram of a GFCI according to an another
5 embodiment of the present invention utilizing two single pole single throw switch devices per line;

FIG. 66b is a partial schematic diagram of a GFCI according to an another embodiment of the present invention utilizing a dual pole single throw switch device with one end shorted per line;

10 FIG. 67 is a partial schematic diagram of a GFCI according to an another embodiment of the present invention utilizing an indicator;

FIG. 68 is a partial schematic diagram of a test connection used to configure a GFCI according to an embodiment of the present invention;

FIGS. 69a-c are flow charts of methods to prepare a circuit interrupting device
15 according to embodiments of the present invention; and

FIG. 70 is a perspective view of a trip force device according to an embodiment of the present invention.

FIGS. 71-76 show a pivot point reset lockout mechanism for a GFCI wherein:

FIG. 71 is a partial side cutaway view of a GFCI similar to the device of FIG. 42
20 according to another embodiment of the present application;

FIG. 72a is a partial side cutaway view of a GFCI similar to the device of FIG. 42 according to another embodiment of the present application;

FIG. 72b is a partial side cutaway view of a GFCI similar to the device of FIG. 1 according to another embodiment of the present application;

25 FIG. 73 is a side elevational view similar to FIG. 56, illustrating another embodiment of the GFCI;

FIGS. 74a-b are perspective sectional view of a reset lockout groove and reset lockout arm in different positions;

FIG. 75a is a sectional view of the banger from the device of FIG. 15;

FIG. 75b is a sectional view of the banger in accordance with the embodiment of the present invention shown in FIG. 73; and

FIGS. 76a-b are perspective sectional view of a reset button and banger in accordance with the embodiment of the present invention shown in FIG. 73.

5 FIGS. 77-91 show an IDCI with reset lockout and independent trip wherein:
FIGS. 77-80 show a first embodiment of the IDCI of the present invention;
FIGS. 81-82 show a second embodiment of the IDCI of the present invention;
FIG. 83 shows a third embodiment of the present invention.

FIG. 84 is a perspective view of one embodiment of as immersion detection circuit
10 interrupting device IDCI according to the present invention;

FIG. 85 is a schematic diagram representation of one embodiment of an IDCI according to the present invention;

FIG. 85a is an exploded perspective view of components of the IDCI;

FIG. 85b is a perspective view of a reset button and trip arm of the IDCI;

15 FIG. 85c is a perspective view of a catch of the IDCI;

FIG. 85d is a perspective view of a latch and latch spring of the IDCI;

FIG. 86 is a top view of an IDCI according to the present application;

FIG. 87 is a partial cutaway perspective view of the IDCI along line 4 shown in a tripped state;

20 FIG. 87a is a partial cutaway perspective view of the IDCI along line 4a shown in a tripped state;

FIG. 87b is a partial cutaway perspective view of the IDCI along line 4b shown in a tripped state;

25 FIG. 87c is a partial cutaway perspective view of the IDCI along line 4c shown in a tripped state;

FIG. 87d is a detail view of section 4d from FIG. 4c;

FIG. 88 is a partial cutaway front view of the IDCI in a reset lockout state;

FIG. 88a is a detail partial section perspective view of the IDCI along line 5a in a reset lockout state;

FIG. 88b is a partial cutaway perspective view of the IDCI along line 5b shown in a reset lockout state;

FIG. 88c is a partial cutaway perspective view of the IDCI along line 5c shown in a reset lockout state;

5 FIG. 89 is a partial cutaway perspective view of the IDCI shown in an intermediate state with plunger moving latch;

FIG. 89a is a detail view of the IDCI shown in an intermediate state with plunger moving latch;

FIG. 90 is a partial cutaway front view of the IDCI in an on state;

10 FIG. 90a is a detail partial section perspective view of the IDCI along line 5a in an on state;

FIG. 90b is a partial cutaway perspective view of the IDCI along line 7b shown in an on state;

15 FIG. 90c is a partial cutaway perspective view of the IDCI along line 7c shown in an on state;

FIG. 91 is a partial cutaway perspective view of the IDCI shown in an intermediate state with manual trip actuator moving latch;

FIGS. 92-95 show an ALCI with reset lockout and independent trip wherein:

20 FIGS. 92a and FIG. 92c are perspective views of an ALCI according to an embodiment of the present invention;

FIGS. 92b and FIG. 92d are perspective views of an ALCI such as a Windmere/TRC ALCI;

FIGS. 93a-93e are perspective views of an IDCI such as Konhan Industries IDCI Catalog No. 303-0118;

25 FIGS. 93f-93g are perspective views of an IDCI according to an embodiment of the present invention;

FIGS. 94a-94f are perspective views of an IDCI such as Electric shock Protection Catalog Nos. ESP-12 and ESP-31;

30 FIGS. 94g-94h are perspective views of an IDCI according to an embodiment of the present invention;

FIGS. 95a-95b are perspective views of an IDCI such as a Wellong Catalog No. P8S;

FIG. 95c is a perspective view of an IDCI according to an embodiment of the present invention;

5 FIGS. 96-97 show a lockout mechanism for an RCD wherein:

FIG. 96 is a schematic representation of the operation of an RCD in a failed condition according to the present application;

FIG. 97 is a schematic representation of the operation of an RCD in a passed condition according to the present application;

10 FIGS. 98-101 show a neutral switch test mechanism for a circuit interrupter wherein:

FIG. 98 is a schematic diagram of a GFCI having an electrical test and bridge circuit according to the present invention;

15 FIG. 99 is a schematic diagram of a GFCI having an independent trip such as a mechanical trip for a test button and an electrical ground fault simulation test for reset lockout according to the present application;

FIG. 100 is a schematic diagram of a GFCI having an independent trip such as a mechanical trip for a test button and a mechanical switch (electrical test) for a neutral fault simulation test for reset lockout according to the present application;

20 FIGS. 101a and 101b is a mechanical switch to effectuate a neutral fault simulation for a GFCI such as that as shown in Application Serial No. TBD, attorney docket 0267-1415CIP9(41912.015600);

FIGS. 102-117 show a reset lockout mechanism and independent trip mechanism for a center latch circuit interrupting device wherein:

25 FIGS. 102a-b is an exploded view of a prior art GFCI;

FIGS. 103a-b is a sectional side view of the mechanism of the prior art GFCI of FIGS. 102a-b;

FIG. 104 is a detailed side view of the mechanism of the prior art GFCI shown in FIGS 103a-b showing the movable contact;

FIG. 105 is a side view of a mechanism of a GFCI according to the present invention;

FIG. 106 is a side view of a GFCI plunger according to the present invention;

FIGS. 107a-c is a side view of the GFCI mechanism during stages of reset according
5 to the present invention;

FIGS. 108a-b is a sectional side view of the mechanism of a prior art GFCI ;

FIG. 109 is a perspective view of one embodiment of a ground fault circuit interrupting device according to the present invention;

FIG. 110 is an exploded view of a portion of a GFCI according to the present
10 invention;

FIGS. 111a-f is a sectional side view of the mechanism of a portion of the GFCI of FIG. 109;

FIG. 112 is an exploded view of a prior art GFCI as shown in FIGS. 108a-b;

FIG. 113 is a perspective view of one embodiment of a ground fault circuit
15 interrupting device according to the present invention;

FIG. 114a is a perspective view of a solenoid plunger of a GFCI according to another embodiment of the present invention according to FIG. 113 as modified from plunger 166 of FIG. 112;

FIG. 114b is a perspective view of a reset button/lift plunger/test contact of a GFCI
20 according to the embodiment of the present invention according to FIG. 113 as modified from 128 of FIG. 112;

FIG. 114c is a perspective view of a trip button of a GFCI according to the embodiment of the present invention according to FIG. 113 as modified from 126 of FIG. 112;

FIG. 114d is a perspective view of a release lever wire of a GFCI according to the
25 embodiment of the present invention according to FIG. 114;

FIG. 114e is a perspective view of a contact carrier with switch attached of a GFCI according to the embodiment of the present invention according to FIG. 113 as modified from 180-182 of FIG. 112;

FIG. 114f is a perspective view of a shuttle/test contact of a GFCI according to the embodiment of the present invention according to FIG. 113 as modified from 178 of FIG. 112;

FIG. 114g is a side and partial top view of the latch of a GFCI according to another embodiment of the present invention that is similar to FIG. 113 as modified from 178 of FIG. 112;

FIGS. 115a-c is a cutaway representation of part of a prior art GFCI.

FIG. 116 is a cutaway representation of part of a GFCI according to an embodiment of the present invention and relates to FIGS. 14a-c; and

FIGS. 117a-b is a cutaway representation of part of a GFCI according to an embodiment of the present invention and relates to FIGS. 115a-c.

FIGS. 118-124 show a circuit interrupter with improved surge suppression wherein:

FIG. 118 illustrates a block diagram of the disclosed suppression and protection circuit connected between power inputs and the GFCI circuit;

FIG. 119 illustrates the circuits and components in FIG. 118 in an example embodiment with greater detail.

FIG. 120 illustrates a schematic diagram of a GFCI circuit having a suppression and protection circuit and a grounded neutral reset lockout test according to an embodiment of the present invention;

FIG. 121 illustrates a schematic diagram of an alternative embodiment of the GFCI circuit of FIG. 3, utilizing a gas tube crowbar device;

FIG. 122a illustrates a spark gap device having a spark gap with a 0.1 inch width;

FIG. 122b illustrates a spark gap device having a spark gap with a 0.04 inch width;

FIG. 122c illustrates a spark gap device having a spark gap with a .05 inch width;

FIG. 122d illustrates a spark gap device with a vertical header pin and an angularly oriented header pin;

FIG. 122e illustrates a spark gap device with two angularly oriented header pins;

FIG. 123a illustrates a gas tube device having a spark gap formed by two vertical header pins;

FIG. 123b illustrates a gas tube device having a spark gap formed by a vertical header pin and an angularly oriented header pin;

FIG. 124a illustrates a hybrid protection circuit for an MOV, having a low pass filter using a Zener diode and a resistor; and

5 FIG. 124b illustrates a hybrid protection circuit for an MOV, having a low pass filter using a Zener diode and an inductor.

FIGS. 125-145 show a GFCI with status indication wherein:

FIG. 125 is a perspective view of a GFCI constructed with status indication capability;

10 FIG. 126 is a bottom perspective view of the GFCI of FIG. 125;

FIG. 127 is similar to FIG. 125 but with the top and bottom covers of the GFCI removed;

FIG. 128 is a perspective view of the mounting strap of the device of FIG. 125;

15 FIG. 129 is a bottom perspective view of the load neutral and load phase terminals of the device of FIG. 125;

FIG. 130 is a perspective view of the printed circuit board and reset assemblies of the device of FIG. 125;

FIG. 131 is a perspective view of the devices of FIG. 130 with the reset lever and PC board removed.

20 FIG. 132 is a perspective view of the bobbin assembly of the device of FIG. 125;

FIG. 133 is a perspective view of the main movable contacts of the device of FIG. 125;

FIG. 134 is a bottom perspective view of the plunger, latch plate and auxiliary contacts of the device of FIG. 125.

25 FIG. 135 is a perspective view showing the transformers mounted on the printed circuit board of the device of FIG. 125;

FIG. 136 is a side elevational view partly in section of the transformer bracket assembly of FIG. 135;

30 FIG. 137 is a perspective view of the test lever and button of the device of FIG. 125.

FIG. 138 is front elevational view of the test lever, test button, test arm and test pin in the open position;

FIG. 139 is a front elevational view of the components shown in FIG. 138 in the closed, test position;

5 FIG. 140 is a perspective view of the reset lever and reset button of the device of FIG. 125;

FIG. 141 is a front elevational view of the reset lever reset button, main contacts and auxiliary contacts in the closed or reset condition;

FIG. 142 is a side elevational view of the device according to FIG. 141;

10 FIG. 143 is a front elevational view of the components of FIG. 141 in the tripped condition;

FIG. 144 is a side elevational view of the device of FIG. 143;

FIG. 145 is a table to show the relationships between the status of the GFCI and associated circuits and the color, speed of blinking and the presence or absence of an
15 audible signal.

DETAILED DESCRIPTION OF EMBODIMENTS

The present invention contemplates various types of circuit interrupting devices that are capable of breaking at least one conductive path at both a line side and a load side of the device. The conductive path is typically divided between a line side that connects to
20 supplied electrical power and a load side that connects to one or more loads. As noted, the various devices in the family of resettable circuit interrupting devices include: ground fault circuit interrupters (GFCI's), arc fault circuit interrupters (AFCI's), immersion detection circuit interrupters (IDCI's), appliance leakage circuit interrupters (ALCI's) and equipment leakage circuit interrupters (ELCI's).

25 For the purpose of the present application, the structure or mechanisms used in the circuit interrupting devices, shown in the drawings and described hereinbelow, are incorporated into a GFCI receptacle suitable for installation in a single-gang junction box used in, for example, a residential electrical wiring system. However, the mechanisms

according to the present application can be included in any of the various devices in the family of resettable circuit interrupting devices.

The GFCI receptacles described herein have line and load phase (or power) connections, line and load neutral connections and user accessible load phase and neutral
5 connections. The connections permit external conductors or appliances to be connected to the device. These connections may be, for example, electrical fastening devices that secure or connect external conductors to the circuit interrupting device, as well as conduct electricity. Examples of such connections include binding screws, lugs, terminals and external plug connections.

10 The circuit interrupting and reset portions described herein preferably use electro-mechanical components to break (open) and make (close) one or more conductive paths between the line and load sides of the device. However, electrical components, such as solid state switches and supporting circuitry, may be used to open and close the conductive paths.

15 Generally, the circuit interrupting portion is used to automatically break electrical continuity in one or more conductive paths (i.e., open the conductive path) between the line and load sides upon the detection of a fault, which in the embodiments described is a ground fault. The reset portion is used to close the open conductive paths. In the embodiments including a reset lockout, the reset portion is used to disable the reset
20 lockout, in addition to closing the open conductive paths. In this configuration, the operation of the reset and reset lockout portions is in conjunction with the operation of the circuit interrupting portion, so that electrical continuity in open conductive paths cannot be reset if the circuit interrupting portion is non-operational, if an open neutral condition exists and/or if the device is reverse wired.

25 In an alternative embodiment, the circuit interrupting devices may also include a trip portion that operates independently of the circuit interrupting portion so that in the event the circuit interrupting portion becomes non-operational the device can still be tripped. Preferably, the trip portion is manually activated and uses mechanical components to break one or more conductive paths. However, the trip portion may use electrical

circuitry and/or electro-mechanical components to break either the phase or neutral conductive path or both paths.

The above-described features can be incorporated in any resettable circuit interrupting device, but for simplicity the descriptions herein are directed to GFCI receptacles. A more detailed description of a GFCI receptacle is provided in U.S. Patent 4,595,894, which is incorporated herein in its entirety by reference and in commonly owned application number 09/688,481, which is incorporated herein in its entirety by reference. It should also be noted that binding screws are exemplary of the types of wiring terminals that can be used to provide the electrical connections. Examples of other types of wiring terminals include set screws, pressure clamps, pressure plates, push-in type connections, pigtails and quick-connect tabs.

Several illustrative embodiments of a center latch GFCI are now provided.

Turning now to FIGS. 1 and 2, a GFCI 30 according to the present invention is shown. GFCI 30 is made up of a top cover 32, middle housing 34 and a bottom housing 36 held in assembly by the deflectable tabs (not shown) on bottom housing 36 engaging the U-shaped members 38 on top cover 32. A mounting strap 40 is mounted between top cover 32 and middle housing 34 and has two apertures 42 to mount the GFCI 30 to the mounting ears of a standard gang box (not shown). Top cover 32 has a face 44 which contains two sets of slots each to receive a three-bladed grounded plug (not shown). Each set of slots is made up of a slot 46, 48 of a first length and a slot 50, 52 of a longer length and a U-shaped slot 54, 56 to receive the grounding prong of the plug. Because the slots 50, 52 are longer than the slots 46, 48 the plug is naturally polarized and conforms to NEMA standard 5-15R. In the depression 58 in top cover 32 is placed a reset button 60, a test button 62 and an indicator lamp means 64. Indicator lamp means 64 is a dual color lamp which produces a first color when a first filament is activated, a second color when a second filament is activated and a third color when both filaments are activated. Bottom housing 36 has a series of four terminal screws (only two of which are shown in the figures). Terminal screw 66 is connected to the load neutral terminal as will be described below. A similar terminal screw 68 is connected to the load phase terminal. Terminal screw 70 is connected to the line neutral terminal and a similar terminal screw 72 is

connected to the line phase terminal as will be described below. Adjacent each terminal screw 66, 68, 70 and 72 are two apertures 74 to receive the bared ends of electrical conductors (not shown). As will be described below, the conductor ends extend between a terminal contact and a wire nut which engages the conductor and pushes it against the terminal contact as the terminal screw is advanced. At the rear wall of middle housing 34 is a grounding screw 76 to which may fastened a ground conductor (not shown inserted into slot 78.)

Turning now to FIG. 3 which shows GFCI 30 with the top cover 32 and the bottom housing 36 removed and FIGS 4 and 5 which show details of the mounting strap 40 and the load phase and neutral terminals. Mounting strap 40 has two apertures 42 as above described and a generally centrally located circular opening 80 to receive the reset lever and a square opening 82 to receive the test lever. Two clips 84, 86 are arranged to engage the grounding prong of inserted plugs and are connected to mounting strap 40 by rivets 88. A bent down tab 90 has a threaded aperture to receive the ground screw 76. A ground nut 92 is pulled against tab 90 as ground screw 76 is advanced to hold the bared end of a conductor inserted in slot 78 and between tab 90 and ground nut 92.

FIG. 5 shows the load neutral terminal 94 and the load phase terminal 96. Each terminal 94, 96 has a central body portion 98, 100, respectively, with male blade grip fingers 102, 104 at each end. The male blades of the plug with fit between each pair of grip fingers 102, 104 to make mechanical and electrical contact with the male blades of the inserted plug. An interned tab 106 on load neutral terminal 94 receives the main fixed neutral contact 106 while interned tab 110 receives the main fixed phase contact 112. A depending three sided tab 114 has a slot 116 to receive therethrough the threaded portion of terminal screw 66. A similar depending three sided tab 118 has a slot 120 to receive therethrough the threaded portion of terminal screw 68.

In FIG. 3 the mounting strap 40 of FIG. 4 and the terminals 94, 96 of FIG. 5 are shown assembled to middle housing 34. Also mounted to middle housing 34 is the printed circuit board (hereafter PCB) 122 which contains the various circuits which determine the indicator lamp means color, its blinking rate and control the beeper. The PCB 122 also contains the various components of the fault detectors, transformers and solenoid as will be

described below. Terminal screw 70 is connected to a tab 124 having a slot 126 therein to receive the threaded portion of terminal screw 70. A similar structure is present for terminal screw 72 not visible in the figure.

Referring now to FIG. 6 the PCB 122 assembly and the reset assembly are shown with the middle housing 34 removed. The reset assembly comprises a reset button 60, a reset lever 128 and a reset spring 130 and a latch pin to be described below with respect to FIGS 16 to 20. A plunger 132 is positioned in the passageway of a solenoid coil 134. The plunger 132 is shown in its reset position extending partially out of the passageway of solenoid coil 134. When the solenoid coil 134 is operated by the circuits on the PCB 122 the plunger 132 is drawn further into solenoid coil 134. The plunger 132 controls the position of the latch plate to be described with reference to FIG. 10. The latch plate in cooperation the latch pin and reset spring 130 move the lifter 136 upwardly against the movable contact arms 138 to close the main movable contacts 140 to the main fixed contacts 108, 112 on the underside of interned tabs 106, 110, respectively. The movable contact arms 138 are biased away from their associated interned tabs 106, 110 and when the latch pin has been released push the lifter 136 and latch plate downwardly to move the movable contacts 140 away from their associated fixed contacts 108, 112. Also mounted on the PCB 122 is a neutral transformer 142 and a differential transformer 144. Only the neutral transformer 142 is shown in FIG. 6. Both transformers and the transformer bracket assembly 146 are shown in FIG. 12. Neutral transformer 142 is stacked upon differential transformer 144 with a fiber washer 148 therebetween. The bracket assembly 146 substantially surrounds the transformers 142, 144 except for a slot 150 as shown in FIG. 11 and slots into which conductors are placed. The leads for the windings of the transformers are brought out to four transformer pins 152 to which may be coupled the line and load conductors. One of the transformers will sense the current going to the load from the source and the other will sense the current from the load back to the source. Any difference in current through these transformers is an indication that there is a fault in the circuit wiring. A device which can measure small differences in current and supply a fault signal is an integrated circuit available from many sources, for example, type number LM1851 from National Semiconductor or type number MC3426 from Motorola. This IC is

located on PCB 122. The line neutral terminal 154 and the line phase terminal 156 have arms 158, 160 (see FIG. 9) which extend through the slots in the top of transformer bracket assembly 146. As shown in FIG. 7, terminal screw 70 extends through slot 126 of tab 124 that is part of line neutral terminal 154 and into a threaded aperture in nut 162 to
5 thus connect the line neutral conductor (not shown) to the two transformers. The arms 158, 160 act as one turn windings for the transformers 142 and 144. The line phase conductor (not shown) is connected via terminal screw 72 to tab 164 which extends through a slot 166 in tab 164 into the threaded aperture of a nut 168. Tab 162 is part of the line phase terminal 156. An insulator 168 extends between the arms 158, 160 to prevent
10 shorting between them. The solenoid coil 134 is connected to two bobbin pins 170 to permit connection to PCB 122. FIG. 7 is similar to FIG. 6 but omits the PCB 122, the reset button 60, the reset lever 128 and the reset spring 130.

FIG. 8 shows the bobbin assembly 172 having solenoid coil 134 connected to bobbin pins 170 and containing plunger 132 in its passageway. A chamber 174 receives the
15 lifter 136 and supports the lifter 136 when in its low position. A cross member 176 supports the auxiliary switch made up of auxiliary fixed contact arm 178 and auxiliary movable contact arm 180. The auxiliary switch when auxiliary fixed contact 186 and auxiliary movable contact 188 are engaged provides power to various components on the PCB 122. The auxiliary switch, when auxiliary fixed contact 186 and auxiliary movable
20 contact 188 are not engaged cut-off the power to the components on PCB 122 and prevent possible damage to the PCB 122 components. For example, if the signal to the solenoid coil 134 were repeatedly applied while the main contacts are open there is a chance to burn out the solenoid coil 134. The auxiliary movable contact arm 180 is biased towards auxiliary fixed contact arm 178 and will engage it unless forced to open the contacts.

25 FIG. 9 shows the lifter 136 in contact with the movable contact arms 138 and positioned by the latch plate 182 which in turn is controlled by the plunger 132 and the plunger reset spring 184. The lifter 136 and latch plate 182 positions are dependent upon the reset lever 128 position as will be described below. The lifter 136 also controls the auxiliary movable contact arm 180. When the lifter 136 in its low position, the auxiliary
30 movable contact 188 is moved away from contact with the auxiliary fixed contact 188 (not

shown). A latch plate return spring (not shown) resets the latch plate once the plunger 132 is reset as will be set out with respect to FIG. 10.

In FIG. 10 there is shown the latch plate 182, the plunger 132 and the auxiliary fixed arm 178 with auxiliary fixed contact 186 and the auxiliary movable arm 180 with auxiliary movable contact 188. Plunger reset spring 184 is anchored on the back edge 200 of latch plate 182 and the tab 198 extending into the rectangular opening 196. When the plunger 132 is moved to the right in FIG. 10 as a result of the activation of solenoid coil 134 the plunger reset spring 184 is compressed and expands to return the plunger 132 to its initial position partially out of the solenoid coil 134 as shown in FIG. 6 when the solenoid coil 134 is deactivated. Latch plate return spring 190 is connected between lifter 136 and tab 198 and is compressed by the movement of latch plate 182 to the right in FIG. 10 due to movement of plunger 132 to the right as well. When the plunger 132 is withdrawn, the latch plate return spring 190 expands to return the latch plate 182 to the left in FIG. 10. The arms 192 support arms of lifter 136. A central aperture 194 is oval in shape with its longer axis extending along a central longitudinal axis of latch plate 182. At the center of aperture 194, the aperture 194 is large enough for a latch pin (not shown) to pass through aperture 194 and move without engaging the lifter 136. At one of the smaller ends the latch pin is held by the latch plate 182 and causes the lifter 136 to move with the latch pin as will be described below. The auxiliary movable arm 180 is biased upwardly so that it brings auxiliary movable contact 188 into contact with auxiliary fixed contact 186 on auxiliary fixed arm 178. As will be described below an arm of the lifter 136 will engage the auxiliary movable arm 180 to push it downwardly in FIG. 10 to separate the auxiliary movable contact 188 from the auxiliary fixed contact 186 and open the auxiliary circuit.

Turning now to FIGS 13, 14 and 15 the test button 62 is shown and its operation described. Test button 62 has a top member 204 from which extend side members 206. Also extending from top member 204 is a central lever 208 which contains a cam 210. The lever 208 extends through square opening 82 in mounting strap 40. The cam 210, when the test button 62 is depressed, engages a test arm 212 and moves its free end 214 into contact with test pin 216. The position of the test pin 216 is shown in FIG. 6. The test pin 216 is coupled to a small resistor and a lead which extends through one of the transformers 142,

144 to produce an unbalance in the power lines and cause the integrated circuit LM1851 to produce a signal to operate the solenoid 134 and thus simulate a fault. The test button return spring (not shown) returns the test button 62 to its initial position. FIG. 14 shows the reset position of test button 64 with cam 210 not depressing test arm 212 and the free end 214 separated from test pin 216. When the test button 62 is depressed as shown in
5 end 214 separated from test pin 216. When the test button 62 is depressed as shown in FIG. 15, the cam 210 forces the free end 214 of test arm 212 downwardly into contact with test pin 216 to cause a simulated fault and operate the GFCI 30 to determine that the GFCI 30 is working properly. When released test button 62 returns to its reset position as shown in FIG. 14.

10 The reset button 60 is shown in FIG. 16. Reset button 60 has a top member 218 from which depend side members 220. Also extending from top member 218 is a latch lever 222 which ends in a latch pin 224. Latch pin 224 is generally pointed at its free end 228. The diameter of latch pin 224 is greater than the diameter of the latch lever 222 resulting in a latch shoulder 226. A reset spring 230 surrounds latch lever 222 as shown in
15 FIG. 17. FIGS 17 and 18 show the GFCI 30 in its reset position. FIG. 17 is a rear view while FIG. 18 is a side elevational view. The surrounding structure is shown in light line to permit the switching components of GFCI 30 to stand out. In FIG. 18 the plunger 132 extends out of the solenoid coil 134 and the latch plate 182 is drawn to the left of the figure so that a smaller end of the oval aperture 194 engages the latch lever 222. The latch pin 224 cannot be drawn through oval aperture 194. The leading end 232 of latch plate 182 rests upon the latch shoulder 226 and also is positioned under lifter 136. The reset spring 230 urges the latch lever 222 upwardly causing the lifter 136 to also move upwardly. This upward movement causes the movable contact arms 138 to also move upwardly bringing movable contacts 140 into contact with fixed contacts 108, 112 (see FIG. 17). The
20 extension 234 of lifter 136 moves away from its contact with auxiliary movable arm 180 and the upwardly biased auxiliary movable arm 180 causes its auxiliary movable contact 188 to engage auxiliary fixed contact 186 on auxiliary fixed arm 178 and thus supply power to the PCB.

In response to an internal or external fault or in response to a test employing test
30 button 62, the GFCI 30, if working properly will go to a trip state shown in FIGS 19 and

20 wherein both the main circuits and the auxiliary circuit will be opened. The presence of the trip condition is signaled by the circuits of the PCB. A signal will be supplied to the solenoid coil 134 which draws the plunger 132 further into solenoid coil 134. Plunger 132 causes the latch plate 182 to move to the right in FIG. 20 and place the central portion of oval aperture 194 over latch pin 224. In this position leading end 232 of the latch plate 182 not longer engages the latch shoulder 226 and the latch lever 222 is free to move through the oval aperture 194. As a result there is nothing to hold the movable contacts 140 on movable contact arms 138 in contact with fixed contacts 108, 112 on the fixed arms 106, 110, respectively. The movable contact arms 138, biased downwardly bear upon the lifter 136 moving it downwardly separating contacts 108, 112 and 140. The extension 234 bears against auxiliary movable arm 180 and causes its downward movement separating the auxiliary movable contact 188 from the auxiliary fixed contact 186 and opening the auxiliary circuit to supply power to the circuits on the PCB. The reset button 60 pops up as a result of the action of reset spring 230 to indicate that the GFCI 30 needs to be reset.

15 In addition to the pop-up of the reset button 60, the GFCI has a dual color indicator lamp means 64 and a piezo resonator 236 driven by an oscillator on the PCB (not shown) to produce an audible output. By selecting the oscillator frequency of 3.0KHZ +/- 20% and controlling the time of operation of the oscillator, the audible signal shall be active for 0.10 second and inactive for 2 seconds. FIG. 21 shows the various combinations of light color, light flashing speed and beeper sound which can be produced to show various states of the GFCI 30. A supervisory signal that indicates that the GFCI 30 is working is provided for the first 25 days of the GFCI 30 cycle. It is recommended that the GFCI 30 be tested and reset every 30 days to ensure that the GFCI 30, is working properly.

25 However, for the most part this instruction is disregarded by users. To encourage the testing of the GFCI 30 the various lights and beeper approach is employed. At the end of 25 days the slow flashing green light which signaled the device as workings changes to a faster blink. The supervisory or slow blink is 0.10 seconds "on" and 15 seconds "off". The faster blink is 0.10 seconds on and 0.9 seconds off. This fast blink extends for five days at which time both filaments of the indicator lamp means 64 are energized to produce an amber light which is blinked at the fast blink rate. If the power comes on reset the amber

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light will also blink at the fast rate until the supervisory condition is reached. The time periods are established by a counter and a clock generator on the PCB. If an external fault is detected the amber light is lit and the audible signal is generated. The GFCI 30 will need to be reset. If the fault is in the GFCI 30 itself, for example the solenoid coil 134 is burned out, then the red filament of the indicator lamp means 64 is activated and the audible signal is generated. The GFCI 30 will have to be replaced if the fault is in the GFCI 30.

A circuit interrupting device having a reset lockout device and a separate user load break point may be desirable.

Referring to FIG. 22, a schematic diagrams of a GFCI according to an embodiment of the present invention is shown having a reset lockout mechanism using an electrical test through R4'.

Referring to FIG. 23, a schematic diagrams of a GFCI according to an embodiment of the present invention is shown incorporating a bridge circuit with reset lockout. As can be appreciated, the bridge circuit can be implemented in the device of FIGS. 1-21 by separately isolating the load side and user load from the line side for each of the phase and neutral lines. For example, bars 98 and 100 need to be modified to isolate tabs 114 and 118 respectfully from tab 102 and its opposing counterpart. An extra contact at 106, 108 would be utilized.

Referring to FIG. 24, a schematic diagrams of a GFCI according to an embodiment of the present invention having a bridge circuit with reset lockout and an independent trip mechanism is shown.

Referring to FIGS. 25-28b, a reset lockout mechanism and independent manual trip are provided for the device of FIGS. 1-21.

The device of FIGS. 1-21 has a reset mechanism that operates as follows. When the reset button is pressed down, the end of the reset pin centers the holes on the latch and the lifter, allowing the reset pin to go through the holes. Once the pin is through the holes, the latch spring moves the latch to its normal position. The device is then in a "reset position" (contact made between line & load). When the solenoid fires (due to a fault or by pressing the test button) the plunger opens the latch and releases the reset pin.

Referring to FIGS. 25-28b, an embodiment of a reset mechanism has a disc 510 toward the end reset shaft 502 attached to reset button 500. When the reset button 500 is pressed down, the reset pin disc 510 interferes with latch 530 because of misalignment between the hole 534 in the latch 530 and the reset pin disc 510 as shown in FIG. 26.

- 5 When this occurs, the device is in a locked out state. Continuing the downward movement of the reset shaft 502 causes the test switch 550 to close. The test, if successful, will cause the solenoid (not shown) to fire, thereby aligning the hole 534 in the latch 530 with the reset pin disc 510. When the reset pin disc 510 passes fully through the latch 530, the latch returns to its normal position shown in FIG. 28 a and a return spring (not shown)
- 10 pulls the reset disc 510 upward into a reset position, thereby closing the contacts (not shown). A manual trip is provided, whereby a test button shaft is angled at a distal end such that it will force latch 532 through a cam action such that the reset pin disc 510 will clear hole 534 and the device will reset.

- Referring to FIGS. 29a-30, another embodiment of a reset mechanism has a reset
- 15 button 600 and a reset end 620. When the reset button 600 is pressed down the latch 640 moves to an opened position as in the embodiment above. In this embodiment, a spacer 650 keeps the latch 640 in its opened position, preventing engagement of the reset pin end 620. The spacer 650 is forced into place, between the lifter 630, latch 640 and bobbin 644 by a spring 652.

- 20 While the reset button 600 is pushed down, the test switch pin 610 activates a test switch 616. If the device is able to fire the solenoid (not shown), it will fire and cause the plunger extension ramp 642 to push the spacer 650 away from the latch 640, allowing it to close. The device is now in a "reset position".

- As can be appreciated, the test switch pin 610 cannot activate the test switch 616
- 25 while the device is in the "reset position" as shown in FIG. 29c.

- As can be appreciated, If the solenoid (not shown) fails to fire for any reason, the reset button 600 can be released by pressing the manual trip button 670 (may be marked test button). When the test button 670 (biased upward by spring 672) is depressed, the profile at the end of the shaft 674 acts as a cam against an arm 676 on the latch 640,
- 30 causing it to open up and release the reset pin end 620 which is biased upward.

As can be appreciated, the reset button 600 can be fully depressed, without obstruction and returned to its upper position without engagement, if the solenoid does not fire for any reason.

Referring to FIGS. 31a-f, various views of the components of the reset lockout
5 mechanism of this embodiment as described above in various stages of operation are shown.

Referring to FIGS. 32a-b, another embodiment of the present invention is shown using a single button activation method for reset lockout. In this embodiment, the device resets as shown in the device of FIG. 25. The lockout method is also the same. When the
10 device is in the reset position, as shown in FIG. 32a, the latch plate 706 moves up in direction C and holds a tilt plate 704 into a "ready" position. At this point, pushing down on the reset button (not shown) causes the latch plate 706 to release the tilt plate 704 when shoulder 712 hits 706. The tilt plate 704 then pushes against the reset pin 702, causing it to tilt forward and remain in that position as shown in FIG. 32b. As the reset button (not
15 shown) is released, the spring (not shown) that biases the reset pin 702 pulls the reset pin upward in direction C, the bottom of the reset pin 710 passes thru the hole in the latch plate 707 because the reset pin 702 is still being tilted as shown in FIG. 32b. When the reset button (not shown) is fully up (not shown), the reset pin 702 acts as a cam, and pushes the tilt plate 704 back into a locked position (not shown). The device has now been
20 tripped manually.

The mechanism of this embodiment allows the device to be placed in a reset position, and then a trip position, with the use of only one button. The operation of the device of this embodiment is similar to that of a latching push button switch.

Referring to FIGS. 33a-f, another embodiment of the present invention is shown
25 using a single button activation method for reset lockout. In this embodiment, the device of FIG. 25 may be used with this single button activation method of the reset lockout mechanism. In this embodiment, a two piece reset button 720 resets and trips the GFCI. The operation of this embodiment is similar to that of a latching push button switch. The device is tripped (contacts open) when the button 720 is up as shown in FIG. 33a. When

the button 720 is pushed down, the device will reset only if the test succeeds. If the test, such as a simulated ground fault, fails, the button 720 will be locked out and will not reset.

Starting with the GFCI in the reset position (power contacts closed). Pushing the button 720 trips the device, and the button 720 comes up. A trip arm 722, connected to the upper part of the reset button 720, uses a cam action to push a trip block 724 against a latch plate 726. The action causes the latch plate 726 to move and release. The device then acts according to the device of FIG. 25. It has a test switch 728. The two piece reset button 720 has two springs 730 and 732 to produce two different actions, when the reset button is pressed. A first portion of travel through a reset button depression may force a mechanical trip, while a second portion may use reset lockout to require a successful test before resetting the device. FIG. 33a shows the device in a tripped, contact open state. FIG. 33b shows the device locked out. FIG. 33e shows the device in a reset, contacts closed state.

Referring to FIGS. 34a-c and 34d-f, two additional embodiments of the present invention are shown using a single button activation method for reset lockout. In this embodiment, the device of FIG. 25 may be used with this single button activation method of the reset lockout mechanism. When the plunger 752, 753 of a reset lock out mechanism is engaged, normally to trip the GFCI mechanically, a separate test or trip button is used. That button may move a sliding plate to a position by which the shaft 752, 753 (plunger) will be free to release (tripped) just as if the solenoid (not shown) fired. As shown in this embodiment, this disengagement can be done with the same reset button 750, 751 where the shaft (plunger) 752, 753 is acting as a lever. With the shaft 752, 753 engaged as shown in FIGS. 34b and e, one can use the button 750, 751 as toggle type switch as shown in FIGS. 34c and f to trip the mechanism.

The use of a GFCI as a representative circuit interrupter is illustrative only and not to be considered limiting. With reference to FIGS. 35-41, a GFCI 810 with a user load activated switching device is shown.

Referring to GFCI 810 of FIG. 35, as shown in FIG. 36a, each time a user inserts a plug having plug blades 811 into the device, a mechanical trip is initiated. User plug blade 811 engages trigger arm 820, that is biased by spring 825. As the trigger arm 820 travels

in direction A, a cam action forces sliding plate 831 that first moves in direction D. The device 810 is mechanically tripped and the reset lockout mechanism must allow a reset before the device 810 will supply power to the user load. As can be appreciated, the user receptacle may exert enough force to hold plug 811 in place despite the force exerted by
5 bias spring 825.

Referring to FIG. 36b, each time a user removes a plug having plug blades 811 from the device, a mechanical trip is initiated. User plug blade 811 engages trigger arm 820, that is biased by spring 825. As the blade 811 travels in direction B, the spring 825 forces trigger arm 820 to travel in direction B and sliding plate 830 first moves in direction
10 C. The device 810 is again mechanically tripped and the reset lockout mechanism must allow a reset before the device 810 will supply power to the user load.

As can be appreciated, a GFCI receptacle with more than one user receptacle may utilize two such switches that may also utilize common components to initiate the trip mechanism. Similarly, the device may be configured to trip only when the first plug is
15 inserted or only when the last plug is removed.

Accordingly, in this embodiment, a user is forced to manually reset the device for each use – a test-to-use arrangement when used with a reset lockout GFCI. In the device of this embodiment employing a reset lock out mechanism, the device will only be reset if the GFCI is operational, not in an open neutral condition and not reverse wired.

20 In this embodiment an independent mechanical trip is initiated. However, a momentary switch may be utilized to provide for an electrical test based trip of the device as described above. The electrical test circuits described above may be utilized to initiate a device trip. Of course, the device may be manufactured or initiated into a reset lock out state as described above. Additionally, the trigger arm bias can be provided with other
25 known means including a trigger arm mounted to provide a spring bias.

With reference to FIGS. 37 and 38a-b, a device with only a reset button is shown. Because the plug will initiate a mechanical trip each time it is inserted or removed, there may be no need for a test or trip button. The device of FIGS. 38a-b is the same as the one of FIGS. 36a-b except there is no test button mechanism.

With reference to FIG. 39, another embodiment of the present invention is shown. An automatic test GFCI device 910 is shown that is configured to automatically test itself when a user load is accessed. A user load activated spring and switch such as shown in FIG. 36a will execute a trip and reset that will be locked out if the device is non-
5 operational, in an open neutral state or reverse wired. When the user plug 811 is removed, the device may again be tripped. As can be appreciated, for a duplex user receptacle such as that of device 810, the first plug inserted may execute the test and reset, while the last plug removed may trip the device into a standby tripped state. Accordingly, because a trip and reset lockout test is accomplished for each plug insertion, there may be no need for
10 user buttons.

As shown in FIG. 40, the mechanism for a buttonless device 910 is shown. Plug prong 911 will engage trigger arm 920, that is biased by spring 925. As the blade 911 travels in direction B, the trigger arm 920 first mechanically trips the device with a low cam forcing sliding plate 931 to release the reset shaft 930 to a tripped position. The
15 trigger arm continues down until it contacts reset shaft 930 and engages a test to reset lock out mechanism as described above. Accordingly, a device may not require any buttons and is preferably delivered in a tripped state.

With reference to FIG. 41, another embodiment of the present invention is shown. An automatic test GFCI device 912 is shown that is similar to device 910, except that the
20 user load switch activation mechanism is activated by pressure on a face plate 916 that is biased to an outward position and forced in when a user plug is inserted.

As noted, although the components used during circuit interrupting and device reset operations are electro-mechanical in nature, the present application also contemplates using electrical components, such as solid state switches and supporting circuitry, as well as
25 other types of components capable of making and breaking electrical continuity in the conductive path.

Turning now to FIG. 42, the GFCI receptacle 310 has a housing 312 consisting of a relatively central body 314 to which a face or cover portion 316 and a rear portion 318 are removably secured. The face portion 316 has entry ports 320 and 321 for receiving normal

or polarized prongs of a male plug of the type normally found at the end of a lamp or appliance cord set (not shown), as well as ground-prong-receiving openings 322 to accommodate a three-wire plug. The receptacle also includes a mounting strap 24 used to fasten the receptacle to a junction box.

5 A test button 326 extends through opening 328 in the face portion 16 of the housing 312. The test button is used to activate a test operation, that tests the operation of the circuit interrupting portion (or circuit interrupter) disposed in the device. The circuit interrupting portion, to be described in more detail below, is used to break electrical continuity in one or more conductive paths between the line and load side of the device. A
10 reset button 330 forming a part of the reset portion extends through opening 332 in the face portion 316 of the housing 312. The reset button is used to activate a reset operation, which reestablishes electrical continuity in the open conductive paths.

Electrical connections to existing household electrical wiring are made via binding screws 334 and 336, where screw 334 is an input (or line) phase connection, and screw
15 336 is an output (or load) phase connection. It should be noted that two additional binding screws 338 and 340 (seen in FIG. 44) are located on the opposite side of the receptacle 310. These additional binding screws provide line and load neutral connections, respectively. A more detailed description of a GFCI receptacle is provided in U.S. Patent 4,595,894, which is incorporated herein in its entirety by reference. It should also be
20 noted that binding screws 334, 336, 338 and 340 are exemplary of the types of wiring terminals that can be used to provide the electrical connections. Examples of other types of wiring terminals include set screws, pressure clamps, pressure plates, push-in type connections, pigtails and quick-connect tabs.

Referring to FIGS. 43-47, the conductive path between the line phase connection
25 334 and the load phase connection 336 includes contact arm 350 which is movable between stressed and unstressed positions, movable contact 352 mounted to the contact arm 350, contact arm 354 secured to or monolithically formed into the load phase connection 336 and fixed contact 356 mounted to the contact arm 354. The user accessible load phase connection for this embodiment includes terminal assembly 358 having two binding
30 terminals 360 which are capable of engaging a prong of a male plug inserted therebetween.

The conductive path between the line phase connection 334 and the user accessible load phase connection includes, contact arm 350, movable contact 362 mounted to contact arm 350, contact arm 364 secured to or monolithically formed into terminal assembly 358, and fixed contact 366 mounted to contact arm 364. These conductive paths are collectively
5 called the phase conductive path.

Similarly, the conductive path between the line neutral connection 338 and the load neutral connection 340 includes, contact arm 370 which is movable between stressed and unstressed positions, movable contact 372 mounted to contact arm 370, contact arm 374 secured to or monolithically formed into load neutral connection 340, and fixed contact 376
10 mounted to the contact arm 374. The user accessible load neutral connection for this embodiment includes terminal assembly 378 having two binding terminals 380 which are capable of engaging a prong of a male plug inserted therebetween. The conductive path between the line neutral connection 338 and the user accessible load neutral connection includes, contact arm 370, movable contact 382 mounted to the contact arm 370, contact
15 arm 384 secured to or monolithically formed into terminal assembly 378, and fixed contact 386 mounted to contact arm 384. These conductive paths are collectively called the neutral conductive path.

Referring to FIG. 43, the circuit interrupting portion has a circuit interrupter and electronic circuitry capable of sensing faults, e.g., current imbalances, on the hot and/or
20 neutral conductors. In a preferred embodiment for the GFCI receptacle, the circuit interrupter includes a coil assembly 390, a plunger 392 responsive to the energizing and de-energizing of the coil assembly and a banger 394 connected to the plunger 392. The banger 394 has a pair of banger dogs 396 and 398 which interact with a movable latching members 1100 used to set and reset electrical continuity in one or more conductive paths.
25 The coil assembly 390 is activated in response to the sensing of a ground fault by, for example, the sense circuitry shown in FIG. 53. FIG. 53 shows conventional circuitry for detecting ground faults that includes a differential transformer that senses current imbalances.

The reset portion includes reset button 330, the movable latching members 1100
30 connected to the reset button 330, latching fingers 1102 and reset contacts 1104 and 1106

that temporarily activate the circuit interrupting portion when the reset button is depressed, when in the tripped position. Preferably, the reset contacts 1104 and 1106 are normally open momentary contacts. The latching fingers 1102 are used to engage side R of each contact arm 350,370 and move the arms 350,370 back to the stressed position where
5 contacts 352,362 touch contacts 356,366, respectively, and where contacts 372,382 touch contacts 376,386, respectively.

The movable latching members 1102 are, in this embodiment, common to each portion (i.e., the circuit interrupting, reset and reset lockout portions) and used to facilitate making, breaking or locking out of electrical continuity of one or more of the conductive
10 paths. However, the circuit interrupting devices according to the present application also contemplate embodiments where there is no common mechanism or member between each portion or between certain portions. Further, the present application also contemplates using circuit interrupting devices that have circuit interrupting, reset and reset lockout portions to facilitate making, breaking or locking out of the electrical continuity of one or
15 both of the phase or neutral conductive paths.

In the embodiment shown in FIG. 43 and 44, the reset lockout portion includes latching fingers 1102 which after the device is tripped, engages side L of the movable arms 330,370 so as to block the movable arms 350,370 from moving. By blocking movement of the movable arms 350,370, contacts 352 and 356, contacts 362 and 366, contacts 372 and
20 376 and contacts 382 and 386 are prevented from touching. Alternatively, only one of the movable arms 350 or 370 may be blocked so that their respective contacts are prevented from touching. Further, in this embodiment, latching fingers 1102 act as an active inhibitor that prevents the contacts from touching. Alternatively, the natural bias of movable arms 350 and 370 can be used as a passive inhibitor that prevents the contacts
25 from touching.

Referring now to FIGS. 43 and 48-52, the mechanical components of the circuit interrupting and reset portions in various stages of operation are shown. For this part of the description, the operation will be described only for the phase conductive path, but the operation is similar for the neutral conductive path, if it is desired to open and close both
30 conductive paths. In FIG. 43, the GFCI receptacle is shown in a set position where

movable contact arm 350 is in a stressed condition so that movable contact 52 is in electrical engagement with fixed contact 356 of contact arm 354. If the sensing circuitry of the GFCI receptacle senses a ground fault, the coil assembly 390 is energized to draw plunger 392 into the coil assembly 390 so that banger 394 moves upwardly. As the banger moves upwardly, the banger front dog 398 strikes the latch member 1100 causing it to pivot in a counterclockwise direction C (seen in FIG. 48) about the joint created by the top edge 1112 and inner surface 1114 of finger 1110. The movement of the latch member 1100 removes the latching finger 1102 from engagement with side R of the remote end 1116 of the movable contact arm 350, and permits the contact arm 350 to return to its pre-stressed condition opening contacts 352 and 356, seen in FIG. 48.

After tripping, the coil assembly 390 is de-energized so that spring 393 returns plunger 392 to its original extended position and banger 394 moves to its original position releasing latch member 1100. At this time, the latch member 1100 is in a lockout position where latch finger 1102 inhibits movable contact 352 from engaging fixed contact 356, as seen in FIG. 51. As noted, one or both latching fingers 1102 can act as an active inhibitor that prevents the contacts from touching. Alternatively, the natural bias of movable arms 350 and 370 can be used as a passive inhibitor that prevents the contacts from touching.

To reset the GFCI receptacle so that contacts 352 and 356 are closed and continuity in the phase conductive path is reestablished, the reset button 330 is depressed sufficiently to overcome the bias force of return spring 1120 and move the latch member 1100 in the direction of arrow A, seen in FIG. 49. While the reset button 330 is being depressed, latch finger 1102 contacts side L of the movable contact arm 350 and continued depression of the reset button 330 forces the latch member to overcome the stress force exerted by the arm 350 causing the reset contact 1104 on the arm 350 to close on reset contact 1106. Closing the reset contacts activates the operation of the circuit interrupter by, for example simulating a fault, so that plunger 392 moves the banger 394 upwardly striking the latch member 1100 which pivots the latch finger 1102, while the latch member 1100 continues to move in the direction of arrow A. As a result, the latch finger 1102 is lifted over side L of the remote end 1116 of the movable contact arm 350 onto side R of the remote end of the movable contact arm, as seen in FIGS. 48 and 52. Contact arm 350 returns to its

unstressed position, opening contacts 352 and 356 and contacts 362 and 366, so as to terminate the activation of the circuit interrupting portion, thereby de-energizing the coil assembly 390.

After the circuit interrupter operation is activated, the coil assembly 390 is de-energized so that so that plunger 392 returns to its original extended position, and banger 394 releases the latch member 1100 so that the latch finger 1102 is in a reset position, seen in FIG. 50. Release of the reset button causes the latching member 1100 and movable contact arm 350 to move in the direction of arrow B (seen in FIG. 50) until contact 352 electrically engages contact 356, as seen in FIG. 43.

As noted above, if opening and closing of electrical continuity in the neutral conductive path is desired, the above description for the phase conductive path is also applicable to the neutral conductive path.

In an alternative embodiment, the circuit interrupting devices may also include a trip portion that operates independently of the circuit interrupting portion so that in the event the circuit interrupting portion becomes non-operational the device can still be tripped. Preferably, the trip portion is manually activated and uses mechanical components to break one or more conductive paths. However, the trip portion may use electrical circuitry and/or electro-mechanical components to break either the phase or neutral conductive path or both paths.

For the purposes of the present application, the structure or mechanisms for this embodiment are also incorporated into a GFCI receptacle, seen in FIGS. 54-61, suitable for installation in a single-gang junction box in a home. However, the mechanisms according to the present application can be included in any of the various devices in the family of resettable circuit interrupting devices.

Turning now to FIG. 54, the GFCI receptacle 1200 according to this embodiment is similar to the GFCI receptacle described in FIGS. 42-53. Similar to FIG. 42, the GFCI receptacle 200 has a housing 12 consisting of a relatively central body 314 to which a face or cover portion 316 and a rear portion 318 are, preferably, removably secured.

A trip actuator 1202, preferably a button, which is part of the trip portion to be described in more detail below, extends through opening 328 in the face portion 316 of the

housing 312. The trip actuator is used, in this exemplary embodiment, to mechanically trip the GFCI receptacle, i.e., break electrical continuity in one or more of the conductive paths, independent of the operation of the circuit interrupting portion.

5 A reset actuator 330, preferably a button, which is part of the reset portion, extends through opening 332 in the face portion 316 of the housing 312. The reset button is used to activate the reset operation, which re-establishes electrical continuity in the open conductive paths, i.e., resets the device, if the circuit interrupting portion is operational.

As in the above embodiment, electrical connections to existing household electrical wiring are made via binding screws 334 and 336, where screw 334 is an input (or line)
10 phase connection, and screw 336 is an output (or load) phase connection. It should be noted that two additional binding screws 338 and 340 (seen in FIG. 44) are located on the opposite side of the receptacle 1200. These additional binding screws provide line and load neutral connections, respectively. A more detailed description of a GFCI receptacle is provided in U.S. Patent 4,595,894, which is incorporated herein in its entirety by
15 reference.

Referring to FIGS. 45-47, 55 and 58, the conductive paths in this embodiment are substantially the same as those described above. The conductive path between the line phase connection 334 and the load phase connection 336 includes, contact arm 350 which is movable between stressed and unstressed positions, movable contact 352 mounted to the
20 contact arm 350, contact arm 354 secured to or monolithically formed into the load phase connection 336 and fixed contact 356 mounted to the contact arm 354 (seen in FIGS. 45, 46 and 58). The user accessible load phase connection for this embodiment includes terminal assembly 358 having two binding terminals 360 which are capable of engaging a prong of a male plug inserted therebetween. The conductive path between the line phase
25 connection 334 and the user accessible load phase connection includes, contact arm 350, movable contact 362 mounted to contact arm 350, contact arm 364 secured to or monolithically formed into terminal assembly 358, and fixed contact 366 mounted to contact arm 364. These conductive paths are collectively called the phase conductive path.

Similarly, the conductive path between the line neutral connection 338 and the load
30 neutral connection 340 includes, contact arm 370 which is movable between stressed and

unstressed positions, movable contact 372 mounted to contact arm 370, contact arm 374 secured to or monolithically formed into load neutral connection 340, and fixed contact 376 mounted to the contact arm 374 (seen in FIGS. 45, 47 and 58). The user accessible load neutral connection for this embodiment includes terminal assembly 378 having two binding
5 terminals 380 which are capable of engaging a prong of a male plug inserted therebetween. The conductive path between the line neutral connection 338 and the user accessible load neutral connection includes, contact arm 370, movable contact 382 mounted to the contact arm 370, contact arm 384 secured to or monolithically formed into terminal assembly 378, and fixed contact 386 mounted to contact arm 384. These conductive paths are collectively
10 called the neutral conductive path.

There is also shown in FIG. 55, mechanical components used during circuit interrupting and reset operations according to this embodiment of the present application. Although these components shown in the drawings are electro-mechanical in nature, the present application also contemplates using semiconductor type circuit interrupting and
15 reset components, as well as other mechanisms capable of making and breaking electrical continuity.

The circuit interrupting device according to this embodiment incorporates an independent trip portion into the circuit interrupting device of FIGS. 42-53. Therefore, a description of the circuit interrupting, reset and reset lockout portions are omitted.

20 Referring to FIGS. 55-57 an exemplary embodiment of the trip portion according to the present application includes a trip actuator 1202, preferably a button, that is movable between a set position, where contacts 352 and 356 are permitted to close or make contact, as seen in FIG. 55, and a trip position where contacts 352 and 356 are caused to open, as seen in FIG. 56. Spring 1204 normally biases trip actuator 1202 toward the set position.
25 The trip portion also includes a trip arm 1206 that extends from the trip actuator 1202 so that a surface 1208 of the trip arm 1206 moves into contact with the movable latching member 1100, when the trip button is moved toward the trip position. When the trip actuator 1202 is in the set position, surface 1208 of trip arm 1202 can be in contact with or close proximity to the movable latching member 1100, as seen in FIG. 55. Of course the
30 trip button may be labeled as a standard test button.

In operation, upon depression of the trip actuator 1202, the trip actuator pivots about point T of pivot arm 1210 (seen in FIG. 56) extending from strap 324 so that the surface 1208 of the trip arm 1206 can contact the movable latching member 1100. As the trip actuator 1202 is moved toward the trip position, trip arm 1206 also enters the path of movement of the finger 1110 associated with reset button 330 thus blocking the finger 1102 from further movement in the direction of arrow A (seen in FIG. 56). By blocking the movement of the finger 1110, the trip arm 1206 inhibits the activation of the reset operation and, thus, inhibits simultaneous activation of the trip and reset operations. Further depression of the trip actuator 1202 causes the movable latching member 1100 to pivot about point T in the direction of arrow C (seen in FIG. 56). Pivotal movement of the latching member 1100 causes latching finger 1102 of latching arm 1100 to move out of contact with the movable contact arm 350 so that the arm 350 returns to its unstressed condition, and the conductive path is broken. Resetting of the device is achieved as described above. An exemplary embodiment of the circuitry used to sense faults and reset the conductive paths, is shown in FIG. 59.

As noted above, if opening and closing of electrical continuity in the neutral conductive path is desired, the above description for the phase conductive path is also applicable to the neutral conductive path.

An alternative embodiment of the trip portion will be described with reference to FIGS. 60 and 61. In this embodiment, the trip portion includes a trip actuator 1202 that at is movable between a set position, where contacts 352 and 356 are permitted to close or make contact, as seen in FIG. 60, and a trip position where contacts 352 and 356 are caused to open, as seen in FIG. 61. Spring 1220 normally biases trip actuator 1202 toward the set position. The trip portion also includes a trip arm 1224 that extends from the trip actuator 1202 so that a distal end 1226 of the trip arm is in movable contact with the movable latching member 1100. As noted above, the movable latching member 1100 is, in this embodiment, common to the trip, circuit interrupting, reset and reset lockout portions and is used to make, break or lockout the electrical connections in the phase and/or neutral conductive paths.

In this embodiment, the movable latching member 1100 includes a ramped portion 1100a which facilitates opening and closing of electrical contacts 352 and 356 when the trip actuator 1202 is moved between the set and trip positions, respectively. To illustrate, when the trip actuator 1202 is in the set position, distal end 1226 of trip arm 1224 contacts the upper side of the ramped portion 1100a, seen in FIG. 60. When the trip actuator 1202 is depressed, the distal end 1226 of the trip arm 1224 moves along the ramp and pivots the latching member 360 about point P in the direction of arrow C causing latching finger 1102 of the latching member 1100 to move out of contact with the movable contact arm 350 so that the arm 350 returns to its unstressed condition, and the conductive path is broken.

Resetting of the device is achieved as described above.

The circuit interrupting device according to the present application can be used in electrical systems, shown in the exemplary block diagram of FIG. 62. The system 1240 includes a source of power 1242, such as ac power in a home, at least one circuit interrupting device, e.g., circuit interrupting device 310 or 1200, electrically connected to the power source, and one or more loads 1244 connected to the circuit interrupting device. As an example of one such system, ac power supplied to single gang junction box in a home may be connected to a GFCI receptacle having one of the above described reverse wiring fault protection, independent trip or reset lockout features, or any combination of these features may be combined into the circuit interrupting device. Household appliances that are then plugged into the receptacle become the load or loads of the system.

A circuit interrupting device having a reset lockout device and a separate user load break point may be desirable.

Referring to FIGS. 63a-b, a prior art circuit interrupting device, GFCI 1300 is shown. Predetermined condition sensor 310 will open switch devices 1312, 1314 in order to isolate the line Phase 1302 and Neutral 1306 from the Load, 1304 and 1308 respectively. As can be appreciated, when the device is reverse wired as shown in FIG. 63b, the user load, receptacle 1320 is not protected by the sensor 1310.

Referring to FIGS. 64a-b, portions of a circuit interrupting device according to another embodiment of the present invention is shown (GFCI 1400). The device is properly wired in FIG. 64a and reverse wired in FIG. 64b. Predetermined condition

sensor 1410 will open switch devices 1412, 1414 in order to isolate the line Phase 1402 and Neutral 1406 from the Load, 1404 and 1408 respectively. As can be appreciated, when the device is reverse wired as shown in FIG. 64b, the user load, receptacle 1420 is protected by the sensor 1410 when the switch devices are tripped. As can be appreciated, if the device does not include a reset lock out, it may be reset, even though it is reverse wired. As shown in FIG. 46 also, a two contact switch 1414 may be utilized to separately break the line connection 1402, 1406 from the load side 1404, 1408 and a user load 1420. Such a configuration can be considered to be a bridge circuit, as shown in FIG. 65a, the configuration may include conductors crossing over in a bridge configuration.

As shown in FIGS. 42-53 and the corresponding detailed description above, a mechanical reset lock out device is provided.

As can be appreciated, multiple failure modes are anticipated for circuit interrupters and they may also be designed to protect against various faults. For instance, GFCIs generally protect against ground current imbalances. They generally protect against grounded neutrals by using two sensing transformers in order to trip the device when a grounded neutral fault occurs. As can be appreciated, a GFCI may protect against open neutrals. Such protection may be provided in corded GFCIs because the wires are flexed, whereas the receptacle GFCI is a fixed installation. Accordingly, as can be appreciated, an open neutral can be protected against by utilizing a constant duty relay solenoid switch powered across the phase and neutral of the line, for example, across 338 and 334 of FIG. 59. In such an instance, if power went out by the neutral opening, the constant duty coil would fire and open the phase and neutral line conductors.

The GFCI of an embodiment of the present invention also protects against reverse wiring.

Referring to FIGS. 65a-b, portions of a circuit interrupting device according to another embodiment of the present invention is shown (GFCI 1401). The device is properly wired in FIG. 65a and reverse wired in FIG. 65b. Predetermined condition sensor 1410 will open switch devices 1412, 1414 in order to isolate the line Phase 1402 and Neutral 1406 from the Load, 1404 and 1408 respectively. As can be appreciated, when the device is reverse wired as shown in FIG. 65b, the user load, receptacle 1420 is

protected by the sensor 1410 when the switch devices are tripped. As can be appreciated, if the device does include a reset lock out, it may not be reset, even though it is reverse wired. The reset lock out will test the device by moving contact 1414 to 1422 along A-B such that a circuit through current limiting resistor 1424 is established and picked up by sensor 1410, preferably a toroid coil. Because a two contact switch 1414 is utilized to separately break the line connection 1402, 1406 from the load side 1404, 1408 and a user load 1420, when reverse wired as in FIG. 65b, the reset lockout test across resistor 1424 will not work because the power from the line is isolated by switch 1414.

Referring to FIGS. 65a-b, circuit interrupting devices 1403, 1405 according to other embodiments of the invention may utilize a bridge circuit in varying configurations. For example, device 1403 preferably utilized two single pole, single throw mechanical switches 1430, 1432 to isolate a line. Other switch devices including semiconductor switches may be used. Furthermore, device 1405 utilizes a ganged double pole, single throw switch with one end tied together 1444.

Referring to FIG. 67, a circuit interrupting device 1407 according to another embodiment of the present invention preferably includes an indicator for providing an indication of a reverse wiring condition. As can be appreciated, the device 1407 with a circuit bridge and reset lock out may have a user load 1420 protected and open from the source of power. The user load may be a receptacle 1420. However, it may be desirable to provide an indication of a reverse wiring condition even if the device is tripped and "safe." Such an indication may relieve user frustration in ascertaining a problem. Accordingly, this embodiment utilizes switches 1452 and 1454 that operate to connect indicator 1450 to the side of the circuit interrupter that normally has the load (1404 and 1408). Switches 1452 and 1454 are preferably mechanical switches ganged with switches 1412 and 1414 respectively. However, other switch devices such as semiconductor switches may be used. If device 1407 is reverse wired as shown and the device is tripped, switches 1452 and 1454 will signal indicator 1450 to activate. The switches preferably switch power to the indicator that is preferably includes a neon lamp. However, other indicators such as audio, visual or communication indicators may be used. Similarly, the indicator 1450 may be powered from a source other than the source of power to the circuit

interrupting device and may be battery powered and may receive only an activate signal from switches 1452 and 1454.

In embodiments of the present invention utilizing a mechanical lock out mechanism, the device may be manufactured such that the circuit interrupter is provided to a user in a
5 reset lock out state.

Referring to FIG. 69a, a method of preparing a circuit interrupting device is provided 1500. As shown, a circuit interrupting device may be manufactured 1510 such that the circuit interrupting device is manufactured in a reset lock out state 1520. The device manufacture is completed 1522. Optionally, the reset button is tested when the
10 device is not powered to ensure that reset is not possible 1524. Thereafter the device 1400 may be placed in the stream of commerce 1526.

Referring to FIG. 69b, a method of preparing a circuit interrupting device is provided 500. As shown, a circuit interrupting device may be manufactured 510 such that the circuit interrupting device is manufactured in a reset lock out state 520. The device
15 manufacture is completed 522. Optionally, the reset button is tested when the device is not powered to ensure that reset is not possible 524. Thereafter the device 400 may be placed in the stream of commerce 526.

Referring to FIGS. 68 and 69c, a method of preparing a circuit interrupting device is provided. A lock out set apparatus such as a test mock up in order to achieve a lock out
20 state may be used before the circuit interrupting device is delivered into the stream of commerce. For example, a GFCI circuit interrupter that has a test mechanism, a reset lock out mechanism and a bridge reverse wiring user load protection mechanism as described above may be manufactured and connected to a power source. The test mechanism may be initiated in order to set the reset lock out mechanism to the lock out state. The GFCI
25 circuit interrupter is then delivered into the stream of commerce in the reset lock out state. As can be appreciated, quality assurance steps may be performed and the manufacture in a tripped state may be part of a quality assurance task. As shown, a circuit interrupting device such as GFCI 1400 may be connected to a test power supply 1490 in order to preset the device into a reset lock out state before shipping it to users. A method of ensuring the
30 device is shipped in the reset lock out state is described 1540. During manufacture 1541 of

the device 1400, a test button is provided 1542. After manufacture, a power source 1490 is connected to the device 1544. The trip test is activated to trip the device, thereby setting a reset lock out state 1546. Thereafter the device 1400 may be placed in the stream of commerce 1548. For example, a quality assurance task may be done with or about 1544.

5 Referring to FIGS. 42 and 70, a trip force device 1610 is provided. As shown, the device has a body 1638 capable of exerting force on a trip force protrusion 1640 when the trip force device is inserted into a receptacle of a circuit interrupting device 310. As can be appreciated, prongs 1631, 1632, 1633 and, 1634 may be inserted into a circuit interrupting device 310 such that protrusion 1640 will depress test button 326.

10 Accordingly, the device 310 will be set to trip when installed. The device 310 may be fitted with such a trip force device 1610 before it is placed into the stream of commerce.

An embodiment that may be described with reference to FIG. 42, is a circuit interrupting device having a face or cover portion 316 and a test button 326. A removable test force tab (not shown) may be attached or molded into cover 316. When a user
15 installed the circuit interrupting device 310, the device would be tripped and a reset lock out state thereby necessarily set. Thereafter, the removable test force tab may be removed and the device will only reset if the circuit interrupter is operational, an open neutral condition does not exist and the device is not reverse wired.

As can be appreciated, if a reset lock out device utilizes electronic means such as
20 nonvolatile memory to store a state condition variable, such device may be manufactured in the reset lock out state or initialized to such a state before delivery.

As noted, although the components used during circuit interrupting and device reset operations are electro-mechanical in nature, the present application also contemplates using electrical components, such as solid state switches and supporting circuitry, as well as
25 other types of components capable of making and breaking electrical continuity in the conductive path.

With reference to FIGS. 71, 72a and 72b, another embodiment of the present invention is described. The GFCI 2300 of this embodiment is similar to the device of FIGS. 42-53 and only the differences are explained. With reference to FIG. 71, GFCI
30 2300 has a reset button 2330, reset latch 2300 and a lockout arm 2305. A test switch 2306

that is not in the same location as the previously described device will connect R4 in to the test circuit when banger 2396 pivots about pivot point 2302.

With reference to FIGS. 72a and 72b, operation of the reset lockout is described. When the GFCI 2301 is in the tripped state (off), the reset button 2330 is in its uppermost position. When a user begins to depress the reset button 2330, the reset latch 2300 will begin downward and lockout arm will force the banger 2396 down until it closes switch 2306. If the test passes and the solenoid fires, the banger will pass lockout arm 2305 and allow the device to reset. Otherwise, the lockout arm 2305 will prevent the reset of the device 2301.

10 Referring to FIGS. 73, 74a, 74b, 75a, 75b, 76a and 76b another embodiment of a GFCI according to the present application is described. Referring to FIG. 73, the GFCI 400 has a reset button 2430 with reset button legs 2405. The banger 2496 has ribs 2497 and a reset lockout wire 2430 having an end 2431 attached to the banger 2496. Referring to FIGS 74a and b, a reset lockout groove is created in the bottom of the housing 2440. The
15 banger ribs 2497 perform a lockout function because wire 2430 prevents the banger 2496 from retracting all the way when the wire is in position B, the lockout position. Thus the ribs prevent the reset button from being depressed.

The operation is as follows. When going to the trip state, the banger 2496 moves, and wire 2430 causes wire tip 2431 to travel in the groove 2442 in a path from point A to
20 B and eventually to C where it comes to a lockout state. In this position, banger 2496 is initially up and ribs 2497 block reset button 2430 from resetting the device 2400. To unlock the device, an electrical test is performed, preferably by the user pressing the test button (not shown). The solenoid (not shown) fires and housing portion 2445 causes the wire tip 2431 to travel from position C through the groove 2422 to position D and
25 eventually E, where the device can be reset because banger ribs 2497 are no longer interfering with reset button legs 2405. Accordingly, the device 2400 is reset and may supply power. Accordingly, the wire 2430 is added to the banger 2496. The housing mould may be configured with portions 2440, 2460, 2445, 2443 and 2450. As can be appreciated from FIG. 74a, housing portion 2450 assures that the wire tip 2431 first takes
30 the path to the left. A ramp 2443 may provide a one-way lock in the groove 2442 such

that the wire tip passes over ramp 2443 near position B and will not retrace its path but go to position C. A notch on housing portion 2445 may ensure that when the solenoid (not shown) fires, the wire tip 2431 will travel from position C to D and eventually E.

Accordingly, a "detent" or "catch and latch" action, similar to that of a push button pen is employed. Once the solenoid (not shown) fires, the banger 2496 would be locked into a forward position. Two ribs 2497 added to the end of the banger 2496 act as stops, preventing the reset button from being able to move to a downward position, thus locking out the reset button as shown in FIGS. 75a-b. In order to reset the device 2400, the solenoid would have to fire, unlocking the banger 2496 from its forward position. When the banger 2496 returns to its backward position, the reset button is free to move down. As can be appreciated, to reset the device 2400 of the present embodiment, the test button must be pressed first. If the device test succeeds (solenoid fires), the device will be able to reset.

As noted, although the components used during circuit interrupting and device reset operations are electro-mechanical in nature, the present application also contemplates using electrical components, such as solid state switches and supporting circuitry, as well as other types of components capable of making and breaking electrical continuity in the conductive path.

Another embodiment of the present invention shown in FIGS. 77-91 are described with reference to the devices of commonly owned application Serial No. 09/379,138 filed August 20, 1999, which is incorporated herein in its entirety by reference. Only the changes from the devices incorporated above will be described.

With reference to Figures 77-80, a first embodiment is described. When the coil is energized, the banger is moved to unlatch the contacts. When this occurs, the latch rises and catches in the latch hole preventing the spring assisted return of the plunger/banger from occurring. Pressing the reset button lowers the latch, releasing the latch hook from the latch hole, allowing reset to occur under normal conditions. If however the SCR has shorted, causing overheating and ultimately coil burnout and plunger seizure, reset is not possible because the banger is holding the latch away from the contacts.

For further assurance that reset is not possible if the coil seizes while latched, the guide posts of the reset button, if lengthened, would be blocked from being pressed, by the banger as explained below.

To ensure that the coil seizes upon over-heating, the plunger can of the coil where
5 the plunger slides can be made of or fitted with a heat-shrinkable material.

With reference to FIGS. 81-82, a second embodiment is described. It is similar in theory to the first embodiment. However, instead of latch/hook set-up, a spring on the underside of the GFCI housing can be placed in the banger guide slot in such a way as to catch the banger guide pin when the coil has been energized.

10 Pressing the reset button pushes the catch spring to allow the plunger-banger to return under normal conditions. Coil seizure will prevent reset as explained in the first embodiment.

Referring to Figure 83, a third embodiment is described. If the coil plunger seizes in the 'ready for reset' position, as it often does, pressing of the reset button can be
15 blocked by modifying the latches as shown in Figure 83. If the banger was seized, pressing reset would try and move the banger to the left but could not, causing reset blockage.

As noted, although the components used during circuit interrupting and device reset operations are electro-mechanical in nature, the present application also contemplates using
20 electrical components, such as solid state switches and supporting circuitry, as well as other types of components capable of making and breaking electrical continuity in the conductive path.

For the purpose of the next embodiment of the present invention, the structure or mechanisms used in the circuit interrupting devices, shown in the drawings (FIGS. 84-91)
25 and described hereinbelow, are incorporated into a IDCI device suitable for installation in an appliance or an appliance power cord. However, the mechanisms according to the present application can be included in any of the various devices in the family of resettable circuit interrupting devices.

A common IDCI utilizes a single switch configured as a dual pole single throw
30 (DPST) switch. In this embodiment of the present invention, S1 comprises a dual pole dual

throw (DPDT) center off switch. A typical IDCI may not have a test circuit. In this embodiment, R4 is used to create a test circuit. A typical IDCI may have a solenoid plunger that is not isolated from the latch. In this embodiment, latch 2070 is isolated from plunger 2086 by insulator 2074 and the plunger 2086 may be shortened to make room for the insulator. A typical IDCI may not have a test feature, as described below, this embodiment uses additional contacts and arms to provide a line powered test of the device without power being applied to the load.

Turning now to FIG. 84, a representative IDCI 1 is shown configured with an IDCI attached at the end of an appliance power cord 2002. A source of power may be connected to line side prongs 2030, 2035. The IDCI of this embodiment has two user interfaces, a reset button 2020 and independent trip lever 2040.

FIG. 85 is a schematic diagram representation of one embodiment of an IDCI according to the present application. As can be appreciated many physical configurations may be utilized in accordance with the teachings of the present invention. S1 is a dual pole dual throw center off switch used for a reset with reset lockout protection using an electrical test of the device. Switch S2 and R4 comprise a test circuit that will exercise the sense circuit and coil. Coil L1 is a solenoid coil that will trigger a trip of the device. A sense wire is positioned to detect immersion and connected to a sense circuit R1, R2, C1, D1 that will trigger SCR to fire coil L1 when a fault is detected.

With reference to FIG. 85a, an exploded view of the IDCI of the present embodiment is shown. A top cover 2005 and bottom cover 2006 are provided with fasteners 2008. A power cord 2002 having phase and neutral wires 2004, 2003 are provided. A strain relief 2007 is provided. A printed circuit board (PCB) 2050 is connected to the bottom cover. A solenoid 2080 having coil 2082, plunger 2086 and plunger bias spring 2084 is connected to the PCB 2050. A trip latch 2070 is biased by latch spring 2072 and mates with catch 2060. Reset button 2020 has a test contact 2022 and is biased by spring 2068. Test contact 2022 is connected to test wire 2024 that attaches to test resistor R4 (not shown). Plugs 2035, 2030 have contacts 2036, 2031 respectively attached. Movable arms 2066, 2062 are connected to the power cord. Arm

2064 is attached to movable arm 2066 using fastener 2054, 2055, 2056. Clamp 2052 is connected to catch 2060. A trip arm 2040 is pivotally connected in reset button 2020.

With reference to FIG. 85b, reset button 2020 is shown with trip arm 2040 and test contact 2022.

5 With reference to FIG. 85c, a catch 2060 is shown. The latch 2070 is slidably connected to the catch 2060 and the reset button 2020 may interact with the latch 2070 inside the catch 2060.

With reference to FIG. 85d, latch 2070 is shown with latch spring 2072 and an insulator 2074 added to insulate the plunger 2086 from the latch 2070.

10 Referring to FIG. 86, a top view of the IDCI is shown.

With reference to FIGS. 87, 87a, 87b, 87c, and 87d, the IDCI is shown in a tripped state. As shown in FIG. 87, the movable arm 2066 and the connected arm 2064 are not in contact with contact 2037 of prong 2035 such that the line circuit is broken. As shown in FIG. 87b, the other movable arm 2062 is also open and not connected to contact 2063 of prong 2030. As can be seen in FIG. 87a, the reset button 2040 is in a raised state as biased by spring 2068. As shown in FIGS. 87c and 87d, the latch 2070 has moved right, releasing reset button 2020 when it is moved from reset button catch 2026.

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With reference to FIG. 88, 88a, 88b, and 88c the device is shown in a reset locked out state. As shown in FIG. 88, the reset button is depressed. As shown in FIG. 89a, test contact 2022 comes in contact with latch 2070. A test circuit is closed through wire 2024 and resistor R4 (not shown). As can be appreciated, if the solenoid coil 2082 does not fire, the reset button will not continue as it is blocked by the latch 2070.

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As shown in FIG. 88c, depressing the reset button will move switch S1B to connect the line neutral to the load neutral conductors using connector 2031 and arm 2062. As shown in FIG. 88b, the arm 2064 and its extension 2064' connect to the phase prong 2036 without energizing movable arm 2066 that is isolated from the appliance plug phase wire 2003. In this way, the IDCI circuit may be powered without powering the appliance.

25

As can be appreciated, the line phase is connected to the test circuit, but not connected to the load phase during the test, as shown in FIG. 85.

As shown in FIGS. 89 and 89a, if the test circuit successfully fires the solenoid 2080, plunger 2086 will strike latch 2070 (at insulator 2074) and will move to the right and reset button 2020 can continue downward such that the IDCI will enter the on state and the reset button will be latched in the catch 2060 by the latch 2070 when it returns to the left under bias of spring 2072.

As shown in FIGS. 90, 90a, 90b, and 90c, the IDCI is in an on state. As shown in FIG. 90a, the reset button 2020 is down in the on state and is latched by latch 2070 in button groove 2026. As shown in FIGS. 90 and 90b, movable arm 2066 is connected to arm 2064 that is connected to prong 2035. As can be appreciated, the circuit is now complete from the line phase prong 2035 to the load phase wire 2003. This differs from the situation above when only the IDCI circuit was connected to the phase of the line side. As shown in FIG. 90c, the neutral side is also closed to complete the neutral circuit from the line side to the load wire 2004 using contact 2063 of prong 2030 and movable arm 2062.

As shown with reference to FIG. 91 an independent trip is described. In this embodiment, the independent trip is a mechanical trip. Trip arm 2040 may be activated by a user pressing it in the X direction. The trip arm 2040 is pivotally connected to pivot 2029 of the reset button 2020. As shown, the trip lever bottom 49 will move in the Y direction, and will force latch 2070 in the Y direction such that the reset button 2040 will be released under bias of spring 2068 and the device will be independently tripped without the solenoid 2080 firing.

As noted, although the components used during circuit interrupting and device reset operations are electro-mechanical in nature, the present application also contemplates using electrical components, such as solid state switches and supporting circuitry, as well as other types of components capable of making and breaking electrical continuity in the conductive path.

An ALCI and IDCI with reset lockout and independent trip are now discussed. Referring now to FIGS. 92b and 92d, a conventional ALCI is shown. Referring to FIGS. 92a and 92c, an ALCI according to an embodiment of the present invention is shown. Reset Lockout prevents a the ALCI from being reset if the device is not functional (or if

the device has no power). It utilizes the same electro-mechanical system to allow reset as was designed to accomplish a trip if a fault were detected. The Mechanical Trip allows a defective or unpowered device to be tripped. A tripped device is a positive indicator to a lay person that the device is defective when the device can't be reset, whereas if the device were to remain operational, it could be mistaken to be safe.

The embodiment differs from the conventional unit as follows. The latch no longer has a "lead-in" taper, causing a tab that is similar to the holding latch edge. (This causes the latch to operate in a similar manner in the reset mode as in the trip mode.) The "test" switch is moved from the external location to an internal point that will operate when a reset is attempted by detecting the extending of the moveable arm of the switched contacts. This arm moves as a result of the force applied to the moveable contact assembly by the tab created on the latch. A mechanical trip lever is added in place of the former test switch.

The embodiment operates as follows. The mechanical Trip is operated to insure that the test is exercised and that the device is put into a tripped state so that if the device is not functional it will not operate. With the unit powered, the reset button is depressed. This pushes the moveable contacts further apart causing the test contact to close, invoking the test cycle. If the test functioned properly, firing the solenoid released the latch from the lockout position, in the same manner as it would have released the latch from the reset position. If the test had failed the latch would not have been released from the lockout position and the device would remain in the safe state. The latch, under manual pressure, travels to the armed side of the moveable contacts, also because the moveable contacts are no longer being forced apart the test switch opens ending the test cycle. The cycle is completed when the reset button is released closing the moveable contacts and powering the device.

Figures 93a-93f show a conventional IDCI and figures 93g-93h show an IDCI according to an embodiment of the present invention incorporating a Reset Lockout and a Mechanical Test method.

Figure 93a is a view of a complete conventional IDCI for a hairdryer.

Figure 93b is an exploded view of latching mechanism. The plunger neck is installed between the two arms of the moving latch when the device is fully assembled.

The moving latch slides into the Contact Carriage (it is fully in the left direction when in the on state and momentarily pulled to the rights in the tripping operation). The moving latch secures the contact carriage to the reset button on the on state. The Penny is shown as a size reference.

5 Figure 93c is a side view of figure 93b. Red arrows show configuration when unit is in the On state (the Moving Latch is installed through the Contact Carriage and the protruding end latches onto the Reset button just below the step on the Reset Button in this view. The penny is shown as a size reference.

10 Figure 93d is a close up exploded view of the Reset button (left) and the Contact Carriage (right). The blue arrows show how the two are attached together in the On state by the Moving Latch.

Figure 93e is a close up picture and drawing of the Contact Carriage. The red lines in the photo highlight the geometry of the Contact Carriage.

15 Figure 93f is a conventional design of the IDCI Reset button and Figure 93g is an embodiment of the present invention (Mechanical Test Method not shown). In the embodiment, the step of the Reset Button will now catch the Moving Latch on its under side in addition to catching on its upper side. If the device is in the Tripped state, pushing the Reset button downward by hand would close the Test Circuit contacts and the plunger would pull to the right. If the solenoid is operational, the plunger would cause the Test
20 contacts to open (preventing repeated firing of the solenoid). The Reset button can then be further pressed downward by hand until the stop would catch the Moving Latch on the underside of the Moving Latch and pull it upwards with the Contact Carriage and put the device online. The moving latch is pushed towards the left in this view by the action of a spring which allows it to be propelled to the left once it has cleared the step of the Reset
25 button on either the top or bottom of this step. The Contact Carriage may be slightly modified to accommodate the new Test contacts. The Mechanical Test Method, illustrated in Figure 93h, calls for the addition of a vertical tab on the Moving Latch. This additional tab is not shown here in the interest of simplicity.

Figure 93h is an IDCI of an embodiment of the present invention. Pressing Test button down hit moving latch which has been modified by the addition of the vertical tab and moves the latch to the right in the same manner as the plunger.

Figures 94a-94f illustrate the current design of the conventional IDCI and figures
5 94g-94h illustrate the IDCI according to the embodiment of the present invention incorporating the reset lockout feature and a mechanical test method.

Figure 94a is a view of complete IDCI. Please note that the solenoid plunger is pushed outward during tripping operation.

Figure 94b is a front view of a conventional IDCI. Note Reset button and contact
10 carriage.

Figure 94c is a close up view of reset button (shown upside-down).

Figure 94d is the front view of the IDCI with the Reset button removed (shown upside-down).

Figure 94e is a side view of the IDCI with the reset button removed.

15 Figure 94f is a three dimensional drawing of contact carriage.

Figure 94g – proposed modification to contact carriage and reset button (this view is a skewed isometric view).

FIG. 94h is a Drawing of the Reset Button and mechanical Test Method. Method
of Operation: If the device is in the tripped state and the Reset button is depressed, the Test
20 contact on the underside of the step on the modified Reset button will make electrical contact with the Test contact that was added to the upper horizontal surface on the Contact Carriage shown in FIG. 94g. When the two Test contacts close, the Solenoid will fire, pushing the lower part of the Reset button to the left in this view causing the step of the Reset button to disengage from the Contact Carriage and the Test contacts to open
25 preventing repeated firing of the solenoid. This will allow the Reset button to be further depressed by hand until the upper surface of the Reset button step engages underneath the lower horizontal surface of the Contact Carriage. When the Reset button is released by the end user, the Contact Carriage is pulled upward (in this view) by the action of the Reset Spring and the device contacts are closed, and the device is pulled on-line. If the Solenoid
30 does not fire, pushing the Reset button will only push the moving contacts further away

from the fixed contacts. When Mechanical Test button is depressed, the ramp on the button causes the Mechanical Test Arm to rotate counterclockwise in this view and hit the bottom portion of the Reset button and deflect the reset button in the same manner as the plunger which then disengages the Reset button from the Contact Carriage and opens the
5 device contacts.

Referring to figures 95a-95b, a conventional IDCI is shown and in Figure 95c, an IDCI according to an embodiment of the present invention is shown. Another embodiment (not shown) eliminates the "Auxiliary contact" and simplifies any modification of a conventional device as this contact will not require modification.

10 The embodiment consists of a means to prevent a defective IDCI (GFCI) from being reset causing power to be applied to a device in which the protection has failed.

This device may accomplish the above goal by altering the Auxiliary contact (The contact removes power from the protection circuitry.) such that the end travel of the reset button when the device is in the tripped state opens this contact. This design may allow
15 power to be applied to the protection circuitry when an attempt to reset the device is initiated (The present design open this contact with an arm on the main contact carrier.).

The embodiment may connect the spring latch (The part that is moved by the solenoid.) to the Line Neutral terminal. (This will be used to activate the Test circuitry.)

The embodiment may have a Reset button that differs from the conventional unit as
20 follows: a) Remove the taper on the bottom end. b) Add a contact on the bottom and up the edge that is opposite the notch. (When depressed, this contact is to connect to the spring latch.) c) Modify the resistor side of the test contact so that it the spring of the reset button makes contact with the reset button and this contact.

The embodiment may modify the function of the test button from an electrical
25 device to a mechanical TRIP function. This may be accomplished by extending a probe from the button through the circuit card to the lever that is operated by the solenoid. The embodiment operates as follows:

1 The Trip Button is depressed. Due to it being a mechanical function, the device is tripped even if the Protection Circuitry is not functional.

2 Depressing the Reset Button establishes power (if connected) to the protection circuit and is blocked by but makes contact with the spring latch.

3 If the protection circuit is functional, the solenoid activates, admitting the probe of the reset button to pass through the latch, breaking the previously established test
5 contact.

4 The test circuit is deactivated (by the loss of contact) and the solenoid and latch spring return. The Reset button is locked in the Reset position.

5 Releasing the Reset button causes the power contacts to engage, completing the sequence.

10 The embodiment reset button may be changed as shown in FIG. 95b to as shown in FIG. 95c. The main change is to remove the lead-in taper to a 90° step so that the notch will not engage the latch without relay/solenoid activation.

As noted, although the components used during circuit interrupting and device reset operations are electro-mechanical in nature, the present application also contemplates using
15 electrical components, such as solid state switches and supporting circuitry, as well as other types of components capable of making and breaking electrical continuity in the conductive path.

The next embodiment of the present invention contemplates various types of circuit interrupting devices that are capable of breaking at least one conductive path at both a line
20 side and a load side of the device. In particular, a shim that will allow operation of an RCD is only allowed to move into operating position if a test passes.

Turning now to FIG. 96, the relevant portions of the RCD are depicted, showing the motion of the mechanism as from an off state to an on state through an intermediate test state. The invention provides a non engagement (lock-out) mechanism for residual current
25 devices (RCD Breakers).

The RCD unit 3100 starts in a tripped state with the user handle 3110 in the off position 1. The user operated reset handle or rocker 3110 can be moved in direction A from an off state 1 to a test state 2. The handle 3110 will move compression arm 3120 such that switch 3130 is closed by contact 3132 connecting with contact 3134. Then a test
30 of the device will occur using the test circuit (not shown). If the test fails, the solenoid

3150 will not move magnet 3160 that is biased by spring 3152 and the shim 3140 will stay in place. Accordingly, the switch 3175 will not close contacts 3170 and 3180 and the device will not pass current and will remain in the off state. When shim 3140 stays in place, the magnet 3160 will not allow the relay 3100 to operate. Relay 3195 is normally
5 biased closed, but the magnet will hold it open.

Referring now to FIG. 97, the device is shown in the state if the test passes. As can be appreciated, if the test switch 3130 causes the solenoid 3150 to fire, the magnet 3160 will be pulled against spring 3152 and the shim 3140 will move down in direction B such that the shim will come down between the solenoid magnet 3160 and magnet 3190 so that
10 the relay will work normally and the handle can progress to the on state. The normally closed relay 3195 will then close.

As noted, although the components used during circuit interrupting and device reset operations are electro-mechanical in nature, the present application also contemplates using electrical components, such as solid state switches and supporting circuitry, as well as
15 other types of components capable of making and breaking electrical continuity in the conductive path.

The features of the next embodiment of the present invention can be incorporated in any resettable circuit interrupting device having neutral fault protection, but for simplicity the descriptions herein are directed to GFCI receptacles.

20 In one embodiment, the GFCI receptacle has a circuit interrupting portion, a reset portion and a reset lockout as shown in commonly owned application serial no. TBD, attorney docket 0267-1415CIP9(41912.015600).

In an embodiment using a mechanical independent trip test button, the present invention utilizes a neutral fault simulation switch that allows resistor R4' to be removed.
25 A new switch such as that shown in FIGS. 101a and 101b will replace a neutral tab such that upon depressing the reset button, when the test is required, it will be accomplished using a neutral fault.

Referring to FIG. 98, a GFCI is described having an electrical test and bridge circuit according to the present application. As can be appreciated a test trip is

accomplished by pushing button 4026 that closes the test circuit through current limiting resistor R4 to create a simulated ground fault to trip the device.

Referring to FIG. 99 a schematic diagram of a GFCI having an independent trip such as a mechanical trip for a test button and an electrical ground fault simulation test for
5 reset lockout according to the present application is shown. As can be appreciated, the reset lockout test is accomplished by using a ground fault simulation through current limiting resistor R4'.

Referring to FIG. 100 a schematic diagram of a GFCI having an independent trip such as a mechanical trip for a test button and a mechanical switch (electrical test) for a
10 neutral fault simulation test for reset lockout according to the present application is shown. As can be appreciated, the schematic shown has an independent mechanical trip for a test, but could have an electrical ground fault simulation test. Similarly, the test button may also fire a neutral fault test simulation. As shown the reset lockout test is accomplished by switch S1 closing and completing a circuit from the line neutral 4038 to the load neutral
15 4040. This circuit creates a feedback path that will trigger the device if it is working properly and the reset will be allowed. As can be appreciated, an open neutral fault can be protected against using a continuous duty solenoid K2 which will open the line side if power drops out such as an open neutral.

The neutral fault condition simulated is generally providing a low impedance path
20 through the two transformers of the GFCI. As can be appreciated, a switch similar to S1 may accomplish a fault simulation by switching a circuit from the line phase 4034 to the load phase 4036.

Certain circuit interrupters do not allow convenient access to the line side. In such situations and others such as high current devices, a third sense line may be used. A third
25 wire through the sense transformers to simulate a fault.

Referring to FIG. 101, an particular neutral fault simulation switch is shown that may be used with the GFCI devices shown above.

As noted, although the components used during circuit interrupting and device reset operations are electro-mechanical in nature, the present application also contemplates using
30 electrical components, such as solid state switches and supporting circuitry, as well as

other types of components capable of making and breaking electrical continuity in the conductive path.

In the next embodiment of the present invention which includes an independent trip portion, electrical continuity in one or more conductive paths can be broken independently of the operation of the circuit interrupting portion. Thus, in the event the circuit
5 interrupting portion is not operating properly, the device can still be tripped.

The features of the next embodiment can be incorporated in any resettable circuit interrupting device, but for simplicity the descriptions herein are directed to GFCI receptacles. A circuit interrupting device having any one or more of a reset lockout
10 mechanism, an independent trip mechanism or a separate user load break point may be desirable.

A portion of the mechanism of a prior art GFCI is shown in FIGS. 102a, 102b, 103a, 103b and 104.

The relevant portion of the operation of the prior art GFCI is summarized as
15 follows. When the reset button 5080 is pressed down the plunger cone forces the latch 5060 to be pressed to the right in FIG. 103a. The latch 5060 will come into a position where the hole in the latch 5060 is aligned with the plunger 5078 such that the conical tip 5078b of the plunger 5078a will pass through the hole. When the plunger goes all the way through the hole, the sliding latch is biased to go back to the left in FIG. 103b, such that
20 the shoulder of the plunger conical tip comes into contact with the latch 5060. When the reset button is released, the plunger 5078 is biased upward and the latch 5060 is pressed upward causing the device to reset and cause contact 5030 to connect to contact 5070 in FIG. 104. If the device trips and the solenoid 5050 causes the plunger 5054 to move latch 5060 to the right, the plunger 5078 will pass upward through latch 5060 and allow the
25 latch, which is biased down to break the contacts.

With reference to FIGS. 105-107, an embodiment of the present invention includes a reset plunger 5078' that includes a notched conical tip 5078b' that forces latch 5060' to act to close switch S1 when the reset plunger 5078' is depressed. When switch S1 is depressed, a circuit is closed from the load phase to the line neutral through a current
30 limiting resistor R.

With reference to FIG. 106, the embodiment of the present invention includes a reset plunger 5078' that includes a notched conical tip 5078b'.

With reference to FIGS. 107a-107c, the reset lockout mechanism of the this embodiment is described. When the reset plunger 5078' starts down in direction A, the latch 5060' is in its leftmost position. The notched plunger tip 5078b' will hit the top of latch 5060' and force it down such that switch S1 is closed to engage a test. As shown in FIG. 107b, in this embodiment, the test is accomplished by completing the circuit from the load phase to the line neutral through a current limiting resistor R. If the circuit interrupting device is operational and properly wired as shown by the test, the solenoid forces plunger 5054 to slide latch 5060' in direction B out from under the notch in 5078b' allowing the reset plunger 5078' to complete its journey in direction A such that latch 5060' will move left and rest atop plunger shoulder 5078c' as shown in FIG. 107c. Thereafter, the reset plunger, when released will pull up latch 5060' under its bias to complete the reset of the device.

As can be appreciated, if the test fails, the latch 5060' will not move in direction B and the notched conical tip 5078b' of the reset plunger 5078' will keep the plunger from going through the hole in the latch 5060' and the device will be locked out from the reset function.

As can be appreciated, a bridge circuit may be implemented to provide reverse wiring protection as described in the pending commonly owned application referenced above. For example, with reference to FIG. 102a of the prior art, a single contact 5068,5070 is utilized to close a circuit to a load phase terminal 5064c and two user load phase terminals 5064a and 5064b through connector 5064. As can be appreciated, terminal 5064c could be isolated from connector 5064 and arm 5024 may utilize a second contact to independently provide a circuit to 5064c. Similarly, the modification would be made to both conductive paths of the device. Furthermore an indicator such as a neon bulb may be utilized to indicate a reverse wiring condition.

As can also be appreciated, the device may be manufactured or initialized into a tripped state and distributed in the tripped state such that a user would be required to reset the device before using it.

A portion of the mechanism of another prior art GFCI is shown in FIGS. 108a, and 108b and is somewhat similar to the previously described prior art unit in some details.

The relevant portion of the operation of the prior art GFCI is summarized as follows. When the reset button 5128 is pressed down the lower cone shaped end of the
5 plunger forces a sliding spring latch to the side until the plunger can go through and the latch will spring back to rest on the shoulder of the sliding spring latch and then pull the device into a reset position.

With reference to FIGS. 109-111f, another embodiment of the present invention includes a GFCI 201 having a reset button 5210 and trip button 5212.

10 With reference to FIG. 110, the reset button 5210 has a bias spring 5210a, a shaft 5210b, a conical tip with step 5210d and the conical tip has a shoulder 5210c. The trip button 5212 has a bias spring 5212a, and a formed wire shaft 5212b. A sliding plate 5214 and sliding spring 5216 fit into grooves of housing 5220 that is mated to solenoid 5218 and solenoid plunger 5218a. Switch 5222 is mounted in the housing under the sliding spring
15 5216.

With reference to FIGS. 111a-f, the operation of the relevant portion of the device is described. FIG. 111a shows the device as in normal operation with current allowed to pass through.

FIG 111b shows the operation when tripped. Solenoid 5218 pulls plunger 5218a
20 and pushes sliding spring 5216 and sliding plate 5214 to the right such that sliding spring 5216 no longer holds down reset plunger shoulder 5210c and the spring bias of spring 5210a forces plunger 5210b upward and the circuit is broken (not shown).

FIG. 111c shows the reset lockout mechanism in use. After the tripped state, when the reset button 5210 is depressed, the step in conical tip 5210d presses down on sliding
25 spring 5216 and forces switch 5222 to close. This view is prior to the solenoid actuation.

FIG. 111d shows the test being completed successfully. The switch 5222 closes the test circuit that causes solenoid 5218 to fire and the plunger forces sliding spring 5216 and sliding plate 5214 to the right, allowing the plunger to continue to travel downward once the plunger tip step 5218d clears the hole in the sliding spring 5216b.

FIG. 111e shows the device after the test is completed. The plunger tip 5210d clears the hole 5216b and the sliding spring releases upward and test switch 5222 opens ending the test cycle. The solenoid 5218 releases plunger 5218' and sliding spring 5216 and sliding plate 5214 return to the left. The sliding spring 216 then rests on top of the plunger tip shoulder 210d and the spring 5210a pulls the spring up to reset the device.

FIG. 111f shows the independent trip mechanism of the device 5201. The independent trip will trip the device without using the sense mechanism or the solenoid. It is preferably a mechanical device, but can be implemented with electronic or electro-mechanical components. As trip button 5212 is pressed downward, formed wire 5212b moves downward and the sloped shape interacts with hole 5214a of sliding plate 5214 to force the sliding plate and sliding spring to the right such that hole 5216b moves enough to allow reset plunger 5210b to release upward and trip the device. Accordingly, the sliding plate 5214 is utilized to move the sliding spring 5216 into alignment. The sliding plate 5214 may be held in place by the middle and bobbin housings. The formed wire 5212b causes a cam action and moves the sliding plate 5214, causing the device to trip.

As can be appreciated, the mechanical trip described will function to trip the device even if the solenoid or other parts are not functioning.

As can be appreciated from the discussion above, a bridge circuit may be implemented to provide reverse wiring protection as described in the pending commonly owned application referenced above. Furthermore an indicator such as a neon bulb may be utilized to indicate a reverse wiring condition. As can also be appreciated, the device may be manufactured or initialized into a tripped state and distributed in the tripped state such that a user would be required to reset the device before using it.

FIG. 112 shows a representative prior art GFCI without a reset lockout mechanism or independent trip.

FIGS. 113 and 114a-114f show modifications to parts of the representative GFCI to facilitate a reset lockout and independent mechanical trip according to another embodiment of the invention.

The primary purpose of the Reset Lockout and Mechanical Trip is to lockout the resetting of a GFCI Type device unless the device is functional, as demonstrated by the

built in test, at the time of reset. The Mechanical Trip is a part of this test cycle by insuring that the device is in the tripped state even if the device is unpowered or non-operational. The means and electronics by which this device trips upon ground fault conditions are not modified. These same means and electronics are now employed as a
5 condition of reset. The test function is incorporated in the reset function, therefore no separate test is required and the test button is employed for a mechanical reset.

As shown in FIGS. 114a-f, the reset plunger 5328 was changed from a semi cone (to lead into the shuttle), to a reverse taper. The diameter of the top edge (the area that latches the contacts closed) remains unchanged so that the holding power and release effort
10 remains unchanged from the original design. The lower end has the taper removed and the diameter increased so that it will not pass through the shuttle unless the shuttle is positioned in the release position by the activation of the solenoid. The shaft notch 5328a is insulated and the bottom 5328b is conductive.

Additionally, the contact carrier 5380 has a contact added 5382 so that when the
15 plunger is in the tripped position, the plunger is connected to the phase line, after the point at which it passes through the sense transformer. Additionally, the shuttle 5378 is wired to the circuit board at the point of the original test contact.

In a further embodiment, another test switch may be used. Pushing the Test button 5326 mechanically trips the plunger by moving the shuttle in the same direction as would
20 the solenoid. This is independent of power or functionality of the unit.

While the large end of the plunger is within the contact carrier, it is connected to the phase line. When the reset button is pressed, the plunger pushes against the shuttle, but does not pass through. The shuttle is the other terminal of the test contact and contacting it with the live plunger initiates the test cycle. If the test is successful, the firing of the
25 solenoid (exactly the same as on the trip cycle) opens the port for the plunger to pass through to the armed position. This causes the large end of the plunger to pass completely through the contact carrier, removing the phase line contact from the plunger, ending the test cycle. Upon release of the reset button, the return spring lifts the shuttle, raising the contact carrier to establish output exactly as before the modification.

In order for the above design to function a momentary operation of the latch solenoid must operate. If this operation is activated via the test circuit their reset of the device also tests the device eliminating the need for the test button to perform an electrical trip. This leaves the test button available to be converted to a mechanical trip mechanism.

5 The reset mechanism could have electrical contacts added such that the base of the plunger (latch) makes contact in the side wall of the guide hole located on the contact carrier of the device. This side wall contact would be connected using a small gauge very flexible conductor to the existing test contact (molded in the solenoid housing or on the PC board). A second connection would be required from the phase load conductor after the
10 point at which it passes through the sense coils to the latch mechanism (the part that is acted on by the solenoid.)

 The reset button is depressed. The plunger on the lower end of the reset button is in electrical contact with its guide hole which in run is wired to the electrical test circuit. When the bottom end of the plunger contacts the latch (which is in electrical contact with
15 phase line) if the device is powered and if the test circuit is functional, the solenoid moves the latch to the open position and the plunger passes through to the opposite side. As the plunger is no longer in electrical contact with the side wall of the guide, the solenoid releases the latch to return to its test position. Releasing the reset button pulls the latch up as in the original design.

20 A mechanical test mechanism may be fashioned by removing and discarding the test electrical contact clip (switch) of FIG. 112.

 As shown in FIG. 114g, a tab with a hole may be added to the part of the latch that is operated by the solenoid in the area of the spring end 5378a. Corresponding holes and mechanism may be added to the test button such that depressing the test button pushes a
25 lever into the hole in the latch that would cause it to move in a manner similar to activation of the solenoid, causing the latch plunger to release on in a normal trip mode.

 The latch (shuttle) is modified to have the "plunger operating hole" size reduced to prevent the plunger from being forced through when the latch is not in the release position.

 Another embodiment is described with reference to FIGS. 115-117. FIGS. 115a-c
30 show a prior art GFCI 5400 in various stages of operation as described.

Referring to FIG. 115a, when the reset button 5430 is pressed down in direction B, a raised edge 5440 on the reset arm 5438 slides down to an angled portion 5451 of a lifter 5450 as shown in FIG. 115c (but shown during a trip). As shown in FIG. 115b and c, the spring 5434 on the reset arm 5438 allows it to move in direction D as it slides past the notch 5451 in the lifter 5450. When the raised edge 5440 of the reset arm 438 clears the lifter 5450, the reset arm moves back in direction C to a vertical position under the bias of spring 5434. The shoulder of the raised edge 5440 then becomes engaged with the bottom of lifter 5450 because the reset arm is under bias upward of reset spring 5436. The device is now reset as shown in FIG. 115b with contact 5458 engaging 5470 and contact 5456 engaging contact 5472. The lifter 5450 is biased down on spring 5452 on the right side of pivot 5454 and the reset mechanism is biased upward by spring 5436. Accordingly, as shown in FIG. 115c, when the solenoid 5462 fires because of a trip or test, the reset bar 5438 is moved in the D direction by plunger 5460 until the raised edge 5440 clears the lifter notch 5451 and the bias spring 5452 forces the circuits open by pushing the lifter 5450 down on the right side of pivot 5454.

Another embodiment of a GFCI 5500 of the present invention is shown with reference to FIGS. 116-117b, and in relation to FIGS. 115a-c. As shown in the prior art FIG. 117a, there is an angled portion of the lifter 451 that is removed as shown in FIG. 117b to create lifter edge 5551. Accordingly, as shown in FIG. 116, the solenoid 5562 must fire and move the reset arm 5538 past the lifter 5550 and edge 5551. If the solenoid does not fire, the reset arm will not be able to pass the lifter as in the prior art device because the angled lifter notch 5451 is removed.

Another arm 5582 is attached to the reset button which makes contact with contact 5584 when reset button 5530 is pressed down in the B direction. The test circuit (not shown) is then completed using current limiting resistor R. this will fire the solenoid 5562 and move the reset arm 5538 past the lifter 5550 allowing the device to reset. If the solenoid 5562 fails to fire for some reason, the device will be locked out and a reset not possible.

In another embodiment, an independent trip mechanism is provided as a mechanical trip feature based upon the test button 5510. When test button 5510 is depressed in the B

direction, angled test bar 5516 cams angled trip bar 5580 in the D direction. This will push the reset bar 5538 and release the reset button to trip the device (not shown). As can be appreciated, FIG. 116 shows the device already tripped. Because allowing the manual trip would not be useful, ribs (not shown) are placed to ensure that the test button may only
5 be depressed when the reset button is down and the device is powered.

Accordingly, the device 5500 may be tripped even if the solenoid 5562 is not able to fire.

As noted, although the components used during circuit interrupting and device reset operations are electro-mechanical in nature, the present application also contemplates using
10 electrical components, such as solid state switches and supporting circuitry, as well as other types of components capable of making and breaking electrical continuity in the conductive path.

The next embodiment is a circuit interrupting device with improved surge suppression. Referring to FIG. 118, the suppression and protection circuit 6010 is shown
15 to interface between power inputs 6012 and a ground fault circuit interrupter (GFCI) circuit 6014 and/or related products connected to a load 6016, with the suppression and protection circuit 10 providing enhanced suppression of transient surges as well as protection from overvoltage conditions. The circuit 6010 includes a filter circuit 6018 and a overvoltage prevention component 6020, which are described in greater detail with reference to FIG.
20 119.

FIG. 119 illustrates one example embodiment of the circuit 6010 and the GFCI 6014. The GFCI 6014 includes a metal oxide varistor (MOV) 6022 positioned between input power lines as the power inputs 6012, for example, an alternating current (AC) line connection having a phase line 6024 and a neutral line 6026. The lines 6024, 6026 are
25 connected through the overvoltage prevention circuit 20, which in an example embodiment is a spark gap device known in the art, and through a ground neutral transformer 6028 and a differential or sensing transformer 6030 to the load 6016, which may include a phase load connection 6032 and the neutral load connection 6034, as in FIG. 119. A test line 6036 may also be provided in a manner known in the art including, for example, a test switch
30 6038 and a resistor R4 having a 15 K Ω resistance. Optionally, a relay 6040 and/or circuit

breaker known in the art may be provided, as further described herein, connecting the differential transformer 6030 to the load lines 6032-6034.

A processor 6042 of the GFCI 6014 is connected via a plurality of pins or connectors to the transformers 6028, 6030 in a manner known in the art, for example, using capacitors C3 and C6-C9, a resistor R4, and a diode D2. In the example embodiment shown in FIG. 119, the resistor R3 has a 100 Ω resistance, and the capacitors C3 and C6-C9 have capacitances of .01 μ F, 100 pF, .0033 μ F, 10 μ F, and 100 pF, respectively, each having a voltage rating of 50 V, except for the capacitor C8 having a voltage rating of 6.3 V.

The processor 6042 may be, for example, a model LM1851 ground fault interrupter controller commercially available from "NATIONAL SEMICONDUCTOR", capable of providing ground fault protection for AC power outlets in consumer and industrial environments. The processor 6042 is also connected via its pins/connectors to the MOV 6022 in a manner known in the art, for example, using capacitors C2 and C4-C5 having capacitances of .01 μ F, 1 μ F, and .018 μ F, respectively, at 50 V; a capacitor C10 having a 680 pF capacitance at 500 V; resistors R1 and R2 having 15 k Ω and 2 M Ω resistances, respectively; a diode D1; a rectifier Q1 such as a silicon controlled rectifier (SCR); and a set of diodes D3-D6 forming a bridge circuit or configuration, as shown in FIG. 119.

The MOV 6022 as well as the filter circuit 6018 are connected to the set of diodes D3-D6. In an example embodiment, the filter circuit 6018 includes an inductor 6044 and a capacitor 46, labeled C1 in FIG. 120 and having a capacitance of, for example, .01 μ F at 400 V. In this example, the filter circuit 6018 functions as an LC low pass filter for input power applied to the MOV 6022.

The inductor 6044 may be a solenoid bobbin acting as a trip coil, such that the inductor 6044 also functions as an actuator to disengage the relay mechanism 6040 on the load side. The capacitor C1 6046 may be normally present in the GFCI product 6014 as a by-pass capacitor. In the disclosed circuit 6010, the capacitor C1 6046 serves as a by-pass capacitor as well as the capacitance in the LC filter of the filter circuit 6018.

In the embodiment shown in FIG. 119, the MOV 6022 clamps the voltage exposed to the capacitor C1 6046 to be within the voltage rating of the capacitor 6046, for example,

400 V. In one example, transient voltage surges of 3 kV or higher are thus clamped down to 400 V or less. As in the prior art, the MOV 6022 itself in a GFCI product 6014 is capable of handling transient surges and overvoltage conditions of, for example, less than 3 kV at 3 kA such as a 100 A surge. Using the LC low pass filter 6018 in the disclosed suppression and protection circuit 6010, transient voltages exceeding, for example, 3 kV at 3 kA and even 6 kV at 3 kA, are suppressed. Accordingly, the MOV 6022 in the GFCI product 6014 is capable of handling voltages exceeding a root-mean-square (RMS) voltage rating of the MOV 6022, permitting the MOV 6022 to survive and provide protection from other transient, surge, and overvoltage conditions, as described herein. Test transients are often configured with standard pulse ramp up and duration time waveforms.

In another embodiment for providing overvoltage protection, the overvoltage prevention circuit 6020 includes the spark gap 6048 which generates arcs across its terminals to perform a breakover at transients exceeding a predetermined voltage, such as 3 kV, and further provides multi-mode surge protection and transient suppression. When breakover occurs, the resulting voltage to the transformer 6028 is approximately 200 V. In addition, the filter 6018 also functions to limit the current to which the MOV 22 is exposed during an overvoltage surge condition. Accordingly, when the current in the MOV 6022 is thus limited, the exposure of the MOV 6022 to RMS voltages beyond the RMS voltage rating of the MOV 6022 does not damage the MOV 6022, and further, does not damage the rest of the GFCI circuit 6014.

In this manner, existing components are combined with other known components to be used as a low pass filter 6018 and to cooperate and function with a spark gap device 6048 to significantly improve surge suppression and overvoltage protection.

Referring to FIGS. 120 and 121, embodiments of the present invention are described. In FIG. 120, as in the above embodiment, an LC low pass filter is utilized 44'. The MOV 6022' is a variable resistance that may have an effect as voltage changes. Similarly a crowbar device 6048' is utilized.

In FIG. 121, as in the above embodiment, an LC low pass filter is utilized 44''. The MOV 6022'' is a variable resistance that may have an effect as voltage changes. Similarly a gas tube crowbar device 6048'' is utilized.

As can be appreciated, a high frequency transient can be attenuated by a series low pass filter. Additionally, a transient may be diverted by absorbing it in a device capable of absorbing energy or shunting it away from a sensitive load.

Voltage clamping devices include without limitation selenium cells, Zener diodes,
5 silicon carbide varistors and metal oxide varistors MOVs. An MOV has a generally fast response time and are commonly used for transient suppression. An MOV will hold a line voltage down while a disproportionately high current flows through it. Source impedance may be relied upon for clamping.

There is uncertainty as to the long term effects on an MOV that is exposed to
10 repeated transient surges and whether there are "aging" effects. While an MOV may or may not continuously degrade as it is exposed to transient voltages, reducing the energy level to the MOV will increase the likelihood that a transient may be suppressed and downstream devices protected.

MOV devices may theoretically be utilized in parallel to absorb more energy.
15 However such devices may have to be closely matched so that they would each be turned on by a transient at nearly the same time. Of course, if one MOV turned on first, it would absorb the full transient. Further, the use of two devices would require greater space and spacing. Such a configuration would also be more costly.

Accordingly a GFCI according to an embodiment of the present invention will
20 reduce energy delivered to the MOV.

Crowbar devices may be utilized as a transient suppressor to divert transients and protect against overvoltage conditions. Such a device will typically short a transient to the return. Crowbar device can include, without limitation, spark gaps, gas tubes and carbon-block protectors. Generally the gas (air for a header spark gap) must avalanche before the
25 crowbar effect is initiated. Accordingly, a 0.10" space header may have too large a gap to provide avalanche in air at an acceptable voltage level for use as a surge suppressor on an AC power line. Accordingly, a more narrow spark gap may be selected.

For example, an over 3000 volt transient may break down across a spark gap and the rest of the circuit will be exposed to an approximately 200V resulting voltage that an
30 MOV may safely suppress. Similarly in an overvoltage condition of 240V, a low pass

filter will limit the current that the MOV is exposed to allowing the MOV to survive beyond its rating.

Referring to FIGs. 122a-122c, various spark gap configurations are shown having differing spark gap widths. As can be appreciated, varying suppression effects may be had
5 with the differing gaps of devices 6110, 6111 and 6112. At header pins 6114 and 6116 at sufficiently high voltages, the air or gas in between the header pins will become ionized and a plasma will develop that will dissipate energy and crowbar the transient voltage to a lower value. As can be appreciated, the base 6118 should withstand the spark energy. The arc or forward drop during the discharge is low such that the device can carry current to a
10 return path without a relatively large power dissipation in the device.

Referring to FIGs. 122d-122e, configurations of a spark gap utilizing a device and related phenomena referred to as a Jacob's ladder are described 6140, 6141. As can be appreciated, having one or two of the header pins 6144, 6146, 6147 at an angle produce a varying spark gap increasing in the vertical direction that will have a varying suppression
15 effect as the spark "walks" up the gap. As can be appreciated, the base 148 should withstand the spark energy.

As can be appreciated, humidity may effect the performance of a spark gap. Accordingly, measures to avoid humid air such as encapsulating the spark gap may be utilized.

20 Referring to FIGs. 123a-123b, various gas tube configurations are shown having differing spark gap widths and may be used as device 6048''. As can be appreciated, varying suppression effects may be had with the differing gaps of devices 6150 and 6151. At header pins 6154 and 6156 at sufficiently high voltages, the air or gas in between the header pins will become ionized and a plasma will develop that will dissipate energy and
25 crowbar the transient voltage to a lower value. As can be appreciated, the base 6158 should withstand the spark energy.

As can be appreciated, the gas 6152 may be contained by tube 6153. Connectors 6155 and 6157 provide connections. Other suitable materials 6152 may be utilized in the spark gap.

Referring to FIGs. 124a and 124b, a hybrid protection circuit may protect the MOV. The voltage clamp device MOV 6180 may be in parallel with a low pass filter or another voltage clamping device such as a Zener diode 6182 and a resistor 6184 or inductor 6186.

5 Additionally, it is known in the art to provide a visual indication that a device equipped with surge suppression is still operating with surge suppression capability. In an embodiment of the present invention, a visual indicator is provided to indicate that the device is operating with adequate surge suppression capability. Similarly, an alarm such as an audio indicator may be provided to indicate that the device is no longer operating with
10 adequate surge suppression capabilities.

Turning now to FIGS. 125 and 126, a complete GFCI 7030 constructed with status indication capability is shown.

GFCI 7030 is made up of a top cover 7032, middle housing 7034 and a bottom housing 7036 held in assembly by the deflectable tabs (not shown) on bottom housing 7036
15 engaging the U- shaped members 7038 on top cover 7032. A mounting strap 7040 is mounted between top cover 7032 and middle housing 7034 and has two apertures 7042 to mount the GFCI 7030 to the mounting ears of a standard gang box (not shown). Top cover 7032 has a face 7044 which contains two sets of slots each to receive a three-bladed grounded plug (not shown). Each set of slots is made up of a slot 7046, 7048 of a first
20 length and a slot 7050, 7052 of a longer length and a U-shaped slot 7054, 7056 to receive the grounding prong of the plug. Because the slots 7050, 7052 are longer than the slots 7046, 7048 the plug is naturally polarized and conforms to NEMA standard 5-15R. In the depression 7058 in top cover 7032 is placed a reset button 7060, a test button 7062 and an indicator lamp means 7064. Indicator lamp means 7064 is a dual color lamp which
25 produces a first color when a first filament is activated, a second color when a second filament is activated and a third color when both filaments are activated. Bottom housing 7036 has a series of four terminal screws (only two of which are shown in the figures). Terminal screw 7066 is connected to the load neutral terminal as will be described below. A similar terminal screw 7068 is connected to the load phase terminal. Terminal screw
30 7070 is connected to the line neutral terminal and a similar terminal screw 7072 is

connected to the line phase terminal as will be described below. Adjacent each terminal screw 7066, 7068, 7070 and 7072 are two apertures 7074 to receive the bared ends of electrical conductors (not shown). As will be described below, the conductor ends extend between a terminal contact and a wire nut which engages the conductor and pushes it
5 against the terminal contact as the terminal screw is advanced. At the rear wall of middle housing 7034 is a grounding screw 7076 to which may fastened a ground conductor (not shown inserted into slot 7078.)

Turning now to FIG. 127 which shows GFCI 7030 with the top cover 7032 and the bottom housing 7036 removed and FIGS. 128 and 129 which show details of the mounting
10 strap 7040 and the load phase and neutral terminals. Mounting strap 7040 has two apertures 7042 as above described and a generally centrally located circular opening 7080 to receive the reset lever and a square opening 7082 to receive the test lever. Two clips 7084, 7086 are arranged to engage the grounding prong of inserted plugs and are connected to mounting strap 7040 by rivets 7088. A bent down tab 7090 has a threaded aperture to
15 receive the ground screw 7076. A ground nut 7092 is pulled against tab 7090 as ground screw 7076 is advanced to hold the bared end of a conductor inserted in slot 7078 and between tab 7090 and ground nut 7092.

FIG. 129 shows the load neutral terminal 7094 and the load phase terminal 96. Each terminal 7094, 7096 has a central body portion 7098, 7100, respectively, with male
20 blade grip fingers 7102, 7104 at each end. The male blades of the plug with fit between each pair of grip fingers 7102, 7104 to make mechanical and electrical contact with the male blades of the inserted plug. An interned tab 7106 on load neutral terminal 7094 receives the main fixed neutral contact 7106 while interned tab 7110 receives the main fixed phase contact 7112. A depending three sided tab 7114 has a slot 7116 to receive
25 therethrough the threaded portion of terminal screw 7066. A similar depending three sided tab 7118 has a slot 7120 to receive therethrough the threaded portion of terminal screw 7068.

In FIG. 127 the mounting strap 7040 of FIG. 129 and the terminals 7094, 7096 of FIG. 130 are shown assembled to middle housing 7034. Also mounted to middle housing
30 7034 is the printed circuit board (hereafter PCB) 7122 which contains the various circuits

which determine the indicator lamp means color, its blinking rate and control the beeper. The PCB 7122 also contains the various components of the fault detectors, transformers and solenoid as will be described below. Terminal screw 7070 is connected to a tab 7124 having a slot 7126 therein to receive the threaded portion of terminal screw 7070. A
5 similar structure is present for terminal screw 7072 not visible in the figure.

Referring now to FIG. 130 the PCB 122 assembly and the reset assembly are shown with the middle housing 7034 removed. The reset assembly comprises a reset button 7060, a reset lever 7128 and a reset spring 7130 and a latch pin to be described below with respect to FIGS 140 to 144. A plunger 7132 is positioned in the passageway of a solenoid
10 coil 7134. The plunger 7132 is shown in its reset position extending partially out of the passageway of solenoid coil 7134. When the solenoid coil 7134 is operated by the circuits on the PCB 7122 the plunger 7132 is drawn further into solenoid coil 7134. The plunger 7132 controls the position of the latch plate to be described with reference to FIG. 135. The latch plate in cooperation the latch pin and reset spring 7130 move the lifter 7136
15 upwardly against the movable contact arms 7138 to close the main movable contacts 7140 to the main fixed contacts 7108, 7112 on the underside of interned tabs 7106, 7110, respectively. The movable contact arms 7138 are biased away from their associated interned tabs 7106, 7110 and when the latch pin has been released push the lifter 7136 and latch plate downwardly to move the movable contacts 7140 away from their associated
20 fixed contacts 7108, 7112. Also mounted on the PCB 122 is a neutral transformer 7142 and a differential transformer 7144. Only the neutral transformer 7142 is shown in FIG. 130. Both transformers and the transformer bracket assembly 7146 are shown in FIG. 137. Neutral transformer 7142 is stacked upon differential transformer 7144 with a fiber washer 7148 therebetween. The bracket assembly 7146 substantially surrounds the
25 transformers 7142, 7144 except for a slot 7150 as shown in FIG. 136 and slots into which conductors are placed. The leads for the windings of the transformers are brought out to four transformer pins 7152 to which may be coupled the line and load conductors. One of the transformers will sense the current going to the load from the source and the other will sense the current from the load back to the source. Any difference in current through these
30 transformers is an indication that there is a fault in the circuit wiring. A device which can

measure small differences in current and supply a fault signal is an integrated circuit available from many sources, for example, type number LM1851 from National Semiconductor or type number MC3426 from Motorola. This IC is located on PCB 7122. The line neutral terminal 7154 and the line phase terminal 7156 have arms 7158, 7160 (see 5 FIG. 133) which extend through the slots in the top of transformer bracket assembly 7146. As shown in FIG. 131, terminal screw 7070 extends through slot 7126 of tab 7124 that is part of line neutral terminal 7154 and into a threaded aperture in nut 7162 to thus connect the line neutral conductor (not shown) to the two transformers. The arms 7158, 7160 act as one turn windings for the transformers 7142 and 7144. The line phase conductor (not 10 shown) is connected via terminal screw 7072 to tab 7164 which extends through a slot 7166 in tab 7164 into the threaded aperture of a nut 7168. Tab 7162 is part of the line phase terminal 7156. An insulator 7168 extends between the arms 7158, 7160 to prevent shorting between them. The solenoid coil 7134 is connected to two bobbin pins 7170 to permit connection to PCB 7122. FIG. 131 is similar to FIG. 130 but omits the PCB 7122, 15 the reset button 7060, the reset lever 7128 and the reset spring 7130.

FIG. 7132 shows the bobbin assembly 7172 having solenoid coil 7134 connected to bobbin pins 7170 and containing plunger 7132 in its passageway. A chamber 7174 receives the lifter 7136 and supports the lifter 7136 when in its low position. A cross member 176 supports the auxiliary switch made up of auxiliary fixed contact arm 7178 20 and auxiliary movable contact arm 7180. The auxiliary switch when auxiliary fixed contact 7186 and auxiliary movable contact 7188 are engaged provides power to various components on the PCB 7122. The auxiliary switch, when auxiliary fixed contact 7186 and auxiliary movable contact 7188 are not engaged cut-off the power to the components on PCB 7122 and prevent possible damage to the PCB 7122 components. For example, if 25 the signal to the solenoid coil 7134 were repeatedly applied while the main contacts are open there is a chance to burn out the solenoid coil 7134. The auxiliary movable contact arm 180 is biased towards auxiliary fixed contact arm 178 and will engage it unless forced to open the contacts.

FIG. 133 shows the lifter 7136 in contact with the movable contact arms 7138 and 30 positioned by the latch plate 7182 which in turn is controlled by the plunger 7132 and the

plunger reset spring 7184. The lifter 7136 and latch plate 7182 positions are dependent upon the reset lever 7128 position as will be described below. The lifter 7136 also controls the auxiliary movable contact arm 7180. When the lifter 7136 in its low position, the auxiliary movable contact 7188 is moved away from contact with the auxiliary fixed
5 contact 7188 (not shown). A latch plate return spring (not shown) resets the latch plate once the plunger 7132 is reset as will be set out with respect to FIG. 7134.

In FIG. 7134 there is shown the latch plate 7182, the plunger 7132 and the auxiliary fixed arm 7178 with auxiliary fixed contact 7186 and the auxiliary movable arm 180 with auxiliary movable contact 7188. Plunger reset spring 7184 is anchored on the back edge
10 7200 of latch plate 7182 and the tab 7198 extending into the rectangular opening 7196. When the plunger 7132 is moved to the right in FIG. 134 as a result of the activation of solenoid coil 7134 the plunger reset spring 7184 is compressed and expands to return the plunger 7132 to its initial position partially out of the solenoid coil 7134 as shown in FIG. 6 when the solenoid coil 7134 is deactivated. Latch plate return spring 7190 is connected
15 between lifter 7136 and tab 7198 and is compressed by the movement of latch plate 7182 to the right in FIG. 7134 due to movement of plunger 7132 to the right as well. When the plunger 7132 is withdrawn, the latch plate return spring 7190 expands to return the latch plate 7182 to the left in FIG. 134. The arms 7192 support arms of lifter 7136. A central aperture 7194 is oval in shape with its longer axis extending along a central longitudinal
20 axis of latch plate 182. At the center of aperture 7194, the aperture 7194 is large enough for a latch pin (not shown) to pass through aperture 7194 and move without engaging the lifter 7136. At one of the smaller ends the latch pin is held by the latch plate 7182 and causes the lifter 7136 to move with the latch pin as will be described below. The auxiliary movable arm 7180 is biased upwardly so that it brings auxiliary movable contact 7188 into
25 contact with auxiliary fixed contact 7186 on auxiliary fixed arm 7178. As will be described below an arm of the lifter 7136 will engage the auxiliary movable arm 7180 to push it downwardly in FIG. 134 to separate the auxiliary movable contact 7188 from the auxiliary fixed contact 7186 and open the auxiliary circuit.

Turning now to FIGS 137, 138 and 139 the test button 7062 is shown and its
30 operation described. Test button 7062 has a top member 7204 from which extend side

members 7206. Also extending from top member 7204 is a central lever 7208 which contains a cam 7210. The lever 7208 extends through square opening 7082 in mounting strap 7040. The cam 7210, when the test button 7062 is depressed, engages a test arm 7212 and moves its free end 7214 into contact with test pin 7216. The position of the test
5 pin 7216 is shown in FIG. 130. The test pin 7216 is coupled to a small resistor and a lead which extends through one of the transformers 7142, 7144 to produce an unbalance in the power lines and cause the integrated circuit LM1851 to produce a signal to operate the solenoid 7134 and thus simulate a fault. The test button return spring (not shown) returns the test button 7062 to its initial position. FIG. 138 shows the reset position of test button
10 7064 with cam 7210 not depressing test arm 7212 and the free end 7214 separated from test pin 7216. When the test button 7062 is depressed as shown in FIG. 139, the cam 7210 forces the free end 7214 of test arm 7212 downwardly into contact with test pin 216 to cause a simulated fault and operate the GFCI 7030 to determine that the GFCI 7030 is working properly. When released test button 7062 returns to its reset position as shown in
15 FIG. 138.

The reset button 7060 is shown in FIG. 140. Reset button 7060 has a top member 7218 from which depend side members 7220. Also extending from top member 7218 is a latch lever 7222 which ends in a latch pin 7224. Latch pin 7224 is generally pointed at its free end 7228. The diameter of latch pin 7224 is greater than the diameter of the latch
20 lever 7222 resulting in a latch shoulder 7226. A reset spring 230 surrounds latch lever 7222 as shown in FIG. 142. FIGS 141 and 142 show the GFCI 7030 in its reset position. FIG. 141 is a rear view while FIG. 142 is a side elevational view. The surrounding structure is shown in light line to permit the switching components of GFCI 7030 to stand out. In FIG. 142 the plunger 132 extends out of the solenoid coil 7134 and the latch plate
25 7182 is drawn to the left of the figure so that a smaller end of the oval aperture 7194 engages the latch lever 7222. The latch pin 7224 cannot be drawn through oval aperture 7194. The leading end 7232 of latch plate 7182 rests upon the latch shoulder 7226 and also is positioned under lifter 7136. The reset spring 7230 urges the latch lever 7222 upwardly causing the lifter 7136 to also move upwardly. This upward movement causes
30 the movable contact arms 7138 to also move upwardly bringing movable contacts 7140 into

contact with fixed contacts 7108, 7112 (see FIG. 141). The extension 7234 of lifter 7136 moves away from its contact with auxiliary movable arm 7180 and the upwardly biased auxiliary movable arm 7180 causes its auxiliary movable contact 7188 to engage auxiliary fixed contact 7186 on auxiliary fixed arm 7178 and thus supply power to the PCB.

5 In response to an internal or external fault or in response to a test employing test button 7062, the GFCI 7030, if working properly will go to a trip state shown in FIGS. 143 and 144 wherein both the main circuits and the auxiliary circuit will be opened. The presence of the trip condition is signaled by the circuits of the PCB. A signal will be supplied to the solenoid coil 7134 which draws the plunger 7132 further into solenoid coil
10 134. Plunger 132 causes the latch plate 182 to move to the right in FIG. 144 and place the central portion of oval aperture 7194 over latch pin 7224. In this position leading end 7232 of the latch plate 7182 no longer engages the latch shoulder 7226 and the latch lever 7222 is free to move through the oval aperture 7194. As a result there is nothing to hold the movable contacts 7140 on movable contact arms 7138 in contact with fixed contacts 7108,
15 7112 on the fixed arms 7106, 7110, respectively. The movable contact arms 7138, biased downwardly bear upon the lifter 7136 moving it downwardly separating contacts 7108, 7112 and 7140. The extension 7234 bears against auxiliary movable arm 7180 and causes its downward movement separating the auxiliary movable contact 7188 from the auxiliary fixed contact 7186 and opening the auxiliary circuit to supply power to the circuits on the
20 PCB. The reset button 7060 pops up as a result of the action of reset spring 7230 to indicate that the GFCI 7030 needs to be reset.

 In addition to the pop-up of the reset button 7060, the GFCI has a dual color indicator lamp means 7064 and a piezo resonator 7236 driven by an oscillator on the PCB (not shown) to produce an audible output. By selecting the oscillator frequency of
25 $3.0\text{KHZ} \pm 20\%$ and controlling the time of operation of the oscillator, the audible signal shall be active for 0.10 second and inactive for 2 seconds. FIG. 145 shows the various combinations of light color, light flashing speed and beeper sound which can be produced to show various states of the GFCI 7030. A supervisory signal that indicates that the GFCI 7030 is working is provided for the first 25 days of the GFCI 7030 cycle. It is

recommended that the GFCI 7030 be tested and reset every 30 days to ensure that the GFCI 7030 , is working properly.

However, for the most part this instruction is disregarded. To encourage the testing of the GFCI 7030 the various lights and beeper approach is employed. At the end of 25
5 days the slow flashing green light which signaled the device as workings changes to a faster blink. The supervisory or slow blink is 0.10 seconds "on" and 15 seconds "off". The faster blink is 0.10 seconds on and 0.9 seconds off. This fast blink extends for five days at which time both filaments of the indicator lamp means 7064 are energized to produce an amber light which is blinked at the fast blink rate. If the power comes on reset the amber
10 light will also blink at the fast rate until the supervisory condition is reached. The time periods are established by a counter and a clock generator on the PCB. If an external fault is detected the amber light is lit and the audible signal is generated. The GFCI 7030 will need to be reset. If the fault is in the GFCI 7030 itself, for example the solenoid coil 7134 is burned out, then the red filament of the indicator lamp means 7064 is activated and the
15 audible signal is generated. The GFCI 7030 will have to be replaced if the fault is in the GFCI 7030.

While there has been shown and described and pointed out the fundamental novel features of the invention as applied to the preferred embodiment, as presently contemplated for carrying them out, it will be understood that various omissions and substitutions and
20 changes of the form and details of the device illustrated and in its operation may be made by those skilled in the art, without departing from the spirit of the invention.

WHAT IS CLAIMED:

1. A circuit interrupting device comprising:
 - a housing;
 - a phase conductive path and a neutral conductive path each disposed at least
5 partially within said housing between a line side and a load side, said phase conductive path
terminating at a first connection capable of being electrically connected to a source of
electricity, a second connection capable of conducting electricity to at least one load and a
third connection capable of conducting electricity to at least one user accessible load, and
said neutral conductive path terminating at a first connection capable of being electrically
10 connected to a source of electricity, a second connection capable of providing a neutral
connection to said at least one load and a third connection capable of providing a neutral
connection to said at least one user accessible load;
 - a circuit interrupting portion disposed within said housing and configured to cause
electrical discontinuity in said phase and neutral conductive paths between said line side
15 and said load side upon the occurrence of a predetermined condition; and
 - a reset portion disposed at least partially within said housing and configured to
reestablish electrical continuity in said phase and neutral conductive paths and connected to
a lever which is operated by the insertion of a user plug; and
 - said circuit interrupting device further comprising a reset lockout portion that
20 prevents reestablishing electrical continuity in said phase and neutral conductive paths if
said circuit interrupting portion is non-operational, if an open neutral condition exists or if
a reverse wiring condition exists.
2. A circuit interrupting device comprising:
 - 25 a housing;
 - a phase conductive path disposed at least partially within said housing between a
line side and a load side, said phase conductive path terminating at a first connection
capable of being electrically connected to a source of electricity, a second connection
capable of conducting electricity to at least one load and a third connection capable of
30 conducting electricity to at least one user accessible load;

a circuit interrupting portion disposed within said housing and configured to cause electrical discontinuity in said phase conductive path between said line side and said load side upon the occurrence of a predetermined condition; and

5 a reset portion disposed at least partially within said housing and configured to reestablish electrical continuity in said phase conductive path.

3. A circuit interrupting device comprising:

a housing;

10 a phase conductive path and a neutral conductive path each disposed at least partially within said housing between a line side and a load side, said phase conductive path terminating at a first connection capable of being electrically connected to a source of electricity, a second connection capable of conducting electricity to at least one load and a third connection capable of conducting electricity to at least one user accessible load, and said neutral conductive path terminating at a first connection capable of being electrically
15 connected to a source of electricity, a second connection capable of providing a neutral connection to said at least one load and a third connection capable of providing a neutral connection to said at least one user accessible load;

20 a circuit interrupting portion disposed within said housing and configured to cause electrical discontinuity in said phase and neutral conductive paths between said line side and said load side upon the occurrence of a predetermined condition; and

a reset portion disposed at least partially within said housing and configured to reestablish electrical continuity in said phase and neutral conductive paths; and

25 said circuit interrupting device further comprising a reset lockout portion that prevents reestablishing electrical continuity in said phase and neutral conductive paths if said circuit interrupting portion is non-operational, if an open neutral condition exists or if a reverse wiring condition exists.

4. A method for distributing a circuit interrupting device having a reset lock out and reverse wiring protection comprising:

30 manufacturing said circuit interrupting device in a reset lock out state; and

placing the circuit interrupting device into the stream of commerce.

5. The method of claim 4 further comprising:
testing the reset lock out before placing the circuit interrupting device into the
5 stream of commerce.

6. A method for distributing a circuit interrupting device having a reset lock out, manual trip and reverse wiring protection comprising:
manufacturing said circuit interrupting device;
10 activating said manual trip in order to set the circuit interrupting device in a reset lock out state; and
placing the circuit interrupting device into the stream of commerce.

7. A circuit interrupting device comprising:
15 a housing at least partially housing a reset lockout mechanism, a line conductor and a load conductor;
a reset lockout mechanism having a lockout member and lockout pathway having a plurality of paths such that the lockout member travels in one pathway after a trip and in another pathway if a predetermined condition enables the device to reset a connection
20 between the line conductor and the load conductor.

8. An GFCI device comprising:
a housing at least partially housing circuit interrupting sensor, a circuit interrupter,
a line conductor and a load conductor;
25 a reset lock out mechanism that does not utilize the circuit interrupter.

9. A circuit interrupting device comprising:
a housing at least partially housing circuit interrupting sensor, a line conductor and
a load conductor;

a double pole double throw center off switch used to power the circuit interrupting sense circuit from the line conductor without powering the user load.

10. An ALCI device comprising:

5 a housing at least partially housing circuit interrupting sensor, a line conductor and a load conductor;

a reset switch having a mechanical trip arm actuator.

11. A residual current device having a reset lockout mechanism comprising:

10 a housing;

a user handle connected to a compression arm; and

a solenoid having a magnetized shaft and a relay connected to the housing;

a shim connected to the compression arm that is slidably engaged to move from a position between the path of the shaft and relay to a position not in between the path of the shaft and the relay.

12. A circuit interrupting device comprising:

a housing;

a phase conductive path and a neutral conductive path each disposed at least partially within said housing between a line side and a load side, said phase conductive path terminating at a first connection capable of being electrically connected to a source of electricity, a second connection capable of conducting electricity to at least one load and a third connection capable of conducting electricity to at least one user accessible load, and said neutral conductive path terminating at a first connection capable of being electrically connected to a source of electricity, a second connection capable of providing a neutral connection to said at least one load and a third connection capable of providing a neutral connection to said at least one user accessible load;

a circuit interrupting portion disposed within said housing and configured to cause electrical discontinuity in said phase and neutral conductive paths between said line side and said load side upon the occurrence of a predetermined condition; and

a reset portion disposed at least partially within said housing and configured to reestablish electrical continuity in said phase and neutral conductive paths; and said circuit interrupting device further comprising a reset lockout portion that prevents reestablishing electrical continuity in said phase and neutral conductive paths only if a
5 neutral fault simulation test is successful.

13. A circuit interrupting device comprising:
- a housing;
 - a phase conductive path disposed at least partially within said housing between a
10 line side and a load side, said phase conductive path terminating at a first connection capable of being electrically connected to a source of electricity, a second connection capable of conducting electricity to at least one load;
 - a circuit interrupting portion disposed within said housing and configured to cause electrical discontinuity in said phase conductive path between said line side and said load
15 side upon the occurrence of a predetermined condition;
 - a reset portion disposed at least partially within said housing and configured to reestablish electrical continuity in said phase conductive path; and
 - wherein said reset portion further comprises a reset lockout portion having a spring
20 biased reset member with protrusion for interfering with a lever latch and a test switch portion to cause a test that clears the interference if successful in order to prevent reestablishing electrical continuity in said phase and neutral conductive paths if said circuit interrupting portion is non-operational, if an open neutral condition exists or if a reverse wiring condition exists.
14. A device for protecting a ground fault circuit interrupter (GFCI) circuit from
25 harmful power conditions, the GFCI including a surge protector component, the device comprising:
- a filter connected across the power inputs of the GFCI circuit for filtering transient power surges to the surge protector component.

15. The device of claim 14, wherein the surge protector component includes a metal oxide varistor (MOV).

16. The device of claim 14, wherein the filter is a low pass filter.

5

17. The device of claim 14, wherein the filter includes an LC circuit having:
a filter capacitor; and
a filter inductor.

10 18. The device of claim 17, wherein the filter capacitor is a by-pass capacitor of the GFCI circuit.

19. The device of claim 17, wherein the filter inductor is a solenoid of the GFCI circuit for actuating a relay between a transformer and a load.

15

20. The device of claim 14, further comprising:
an overvoltage prevention circuit, including a spark gap device connected across the power inputs of the GFCI circuit.

20 21. The device of claim 20, wherein, during an overvoltage condition, the overvoltage prevention circuit limits the voltage applied to the surge protection component, and the filter limits the current applied to the surge protection component.

22. A ground fault circuit interrupter (GFCI) circuit comprising:
25 a surge protector component connected across a set of power inputs;
a by-pass capacitor connected to the surge protector component;
a bridge circuit connected to the surge protector component and including a plurality of diodes;
a GFCI processor connected to the bridge circuit;
30 a ground transformer connected to the GFCI processor;

a sensing transformer connected to the GFCI processor;

a solenoid;

a relay mechanism actuated by the solenoid, wherein the ground transformer, the sensing transformer, and the relay mechanism connect the set of power inputs to a load;

5 and

a suppression and protection circuit connected to the surge protector component and including:

a filter connected across the power inputs for filtering transient power surges to the surge protector component.

10

23. The GFCI circuit of claim 22, wherein the surge protector component includes a metal oxide varistor (MOV).

24. The GFCI circuit of claim 22, wherein the filter is a low pass filter.

15

25. The GFCI circuit of claim 22, wherein the filter includes an LC circuit having:

a filter capacitor; and

a filter inductor.

20

26. The GFCI circuit of claim 25, wherein the filter capacitor is the by-pass capacitor.

27. The GFCI circuit of claim 25, wherein the filter inductor is the solenoid.

25

28. The GFCI circuit of claim 25, further comprising:

an overvoltage prevention circuit, including a spark gap device connected across the power inputs.

29. The GFCI circuit of claim 28, wherein, during an overvoltage condition, the overvoltage prevention circuit limits the voltage applied to the surge protection component, and the filter limits the current applied to the surge protection component.

5 30. A method for protecting a ground fault circuit interrupter (GFCI) circuit from harmful power conditions, the GFCI including a surge protector component, the method comprising the step of:
 filtering transient power surges from power inputs to the surge protector component using a low pass filter.

10

31. The method of claim 30, wherein the step of filtering is performed by an LC circuit, having a capacitor and an inductor, as the low pass filter.

32. The method of claim 30, further comprising the step of:
15 reducing voltages to the surge protector component during overvoltage conditions using a spark gap device connected across the power inputs.

33. The method of claim 32, wherein, during an overvoltage condition, the spark gap device limits the voltage applied to the surge protection component, and the filter
20 limits the current applied to the surge protection component.

34. A switching device for selectively interrupting electrical connections between two input and two output conductors or the like, comprising:
 a housing having an outer shell;
25 two first fixed contacts, one for each of said two output conductors within said housing;
 two first movable contacts, one for each of said two input conductors, within said housing, to be selectively moved into contact with an associated first fixed contact;
 a lifter member to selectively move both of said two first movable contacts into
30 contact with an associated first fixed contact;

a reset lever having a reset button at a first end and a latch pin at a second end;
a latch spring about said reset lever to urge said reset lever towards said housing
outer shell; and

a latch plate for selectively engaging said latch pin; said latch plate being movable
5 between a first position in contact with said latch pin to retain said lifter member in contact
with said first movable contacts which are in turn in contact with said first fixed contacts
and a second position wherein said latch pin is free to move through said lifter member
under the influence of said latch spring and permits the separation of said first movable and
first fixed contacts.

10

35. A switching device, as claimed in Claim 34, wherein said first movable
contacts displace said lifter member to open said two first movable contacts with respect to
said associated first fixed contacts when said latch plate is in said second position.

15

36. A switching device, as defined in Claim 34, further comprising:
a plunger coupled to said latch plate to control the position of said latch plate; and
a solenoid having two input terminals for selectively receiving thereout a trip
current to cause said solenoid to act as a magnet when trip current is applied to said two
input terminals and draw said plunger into said solenoid and cause said latch plate to move
20 to said second position and when no trip current is applied to said two input terminals
allow said latch plate to be moved to said first position.

20

37. A switching device, as defined in Claim 34, further comprising:
a reset spring coupled to said latch plate to move said latch plate from said second
25 position to said first position.

25

38. A switching device as defined in claim 36, further comprising:
a reset spring coupled to said latch plate and said plunger to move said latch plate
from said second position to said first position in the absence of trip current to said two
30 input terminals of said solenoid.

30

39. A switching device, as defined in Claim 38, wherein said reset spring is two reset springs one connected between said latch plate and said plunger and a second connected between said lifter member and said latch plate.

5

40. A switching device, as defined in Claim 34, further comprising:

a second fixed contact;

a second movable contact;

an extension on said lifter member to engage said second movable contact to cause
10 said second movable contact to engage said second fixed contact when said latch plate is in
said first position and permit separation of said second movable contact from said second
fixed contact when said latch plate is in said second position.

41. A switching device, as defined in Claim 36, further comprising:

15 a test switch coupled to said solenoid to impress trip current thereon to move said
latch plate from said first position to said second position.

42. A switching device, as defined in Claim 34, further comprising:

indicator lamp means; and

20 blinker means coupled to said indicator lamp means to blink said indicator lamp
means at regular intervals.

43. A switching device, as defined in Claim 36, further comprising:

indicator lamp means; and

25 blinker means coupled to said indicator lamp means to blink said indicator lamp
means at regular intervals.

44. A switching device as defined in Claim 34, further comprising:

indicator lamp means;

blinking means coupled to said indicator lamp means to blink said indicator lamp means at regular intervals; and

audible signal means for producing an audible signal whereby the condition of said switching device can be determined by a state of said indicator lamp means and an audible
5 signal.

45. A switching device, as defined in Claim 36, further comprising:
indicator lamp means;

blinker means coupled to said indicator lamp means to blink said indicator lamp
10 means at regular intervals; and

audible signal means for producing an audible signal whereby the condition of said switching device can be determined by a state of said indicator lamp means and an audible
signal.

15 46. A switching device, as defined in Claim 45, wherein said indicator lamp is a dual color lamp which can produce three distinct colors.

47. A switching device, as defined in Claim 46, wherein said indicator lamp is a dual color lamp which can produce three distinct colors.

20

48. A switching device, as defined in Claim 47, wherein said blinking means can operate at two different speeds.

25 49. A switching device, as defined in Claim 48, wherein said blinking means can operate at two different speeds.

50. A switching device, as defined in Claim 47, wherein said blinking means can operate at two different speeds and the condition of the switching device can be determined from the color and speed of blink of said indicator lamp means and the
30 presence or absence of an audible signal.

51. A switching device, as defined in Claim 48, wherein said blinking means can operate at two different speeds and the condition of the switching device can be determined from the color and speed of blink of said indicator lamp means and the presence or absence of an audible signal.

52. A switching device, as defined in Claim 51, wherein said indicator lamp means is blinked at a first speed in a first color and the absence of said audible signal together show a successful test sequence of the switching device has been completed.

10

53. A switching device, as defined in Claim 52, wherein said indicator lamp means is blinked at a first speed in a first color and the absence of said audible signal together show a successful test sequence of the switching device has been completed.

54. A switching device, as defined in Claim 51, wherein said indicator lamp means is blinked at a second speed faster than said first speed in said first color and the absence of said audible signal together to show that the time for again testing the switching device is approaching.

55. A switching device, as defined in Claim 52, wherein said indicator lamp means is blinked at a second speed faster than said first speed in said first color and the absence of said audible signal together show that the time for again testing the switching device is approaching.

56. A switching device, as defined in Claim 51, wherein said indicator lamp means is blinked at said second speed in a second color and the absence of said audible signal to show that the time for testing the switching means has arrived.

25

101

57. A switching device, as defined in Claim 52, wherein said indicator lamp means is blinked at said second speed in a second color and the absence of said audible signal to show that the time for testing the switching means has arrived.

5 58. A switching device as defined in Claim 51, wherein said indicator lamp means is blinked at said second speed in a second color and in the presence of an audible signal to show that the switching device has tripped due to an external fault.

59. A switching device, as defined in Claim 52, wherein said indicator lamp
10 means is blinked at said second speed in a second color and in the presence of an audible signal to show that the switching device has tripped due to an external fault.

60. A switching device, as defined in Claim 51, wherein said indicator lamp
15 means is blinked at said second speed in a third color and in the presence of an audible signal to show that the switching device has tripped due to an internal fault in the switching device.

61. A switching device, as defined in Claim 52, wherein said indicator lamp
20 means is blinked at said second speed in a third color and in the presence of an audible signal to show that the switching device has tripped due to an internal fault in the switching device.

62. A switching device, as defined in Claim 51, wherein said indicator lamp
25 means is blinked at said second speed in said second color and in the absence of an audible signal to show that the power is on upon reset.

63. A switching device, as defined in Claim 52, wherein said indicator lamp means is blinked at said second speed in said second color and in the absence of an audible signal to show that the power is on upon reset.

30

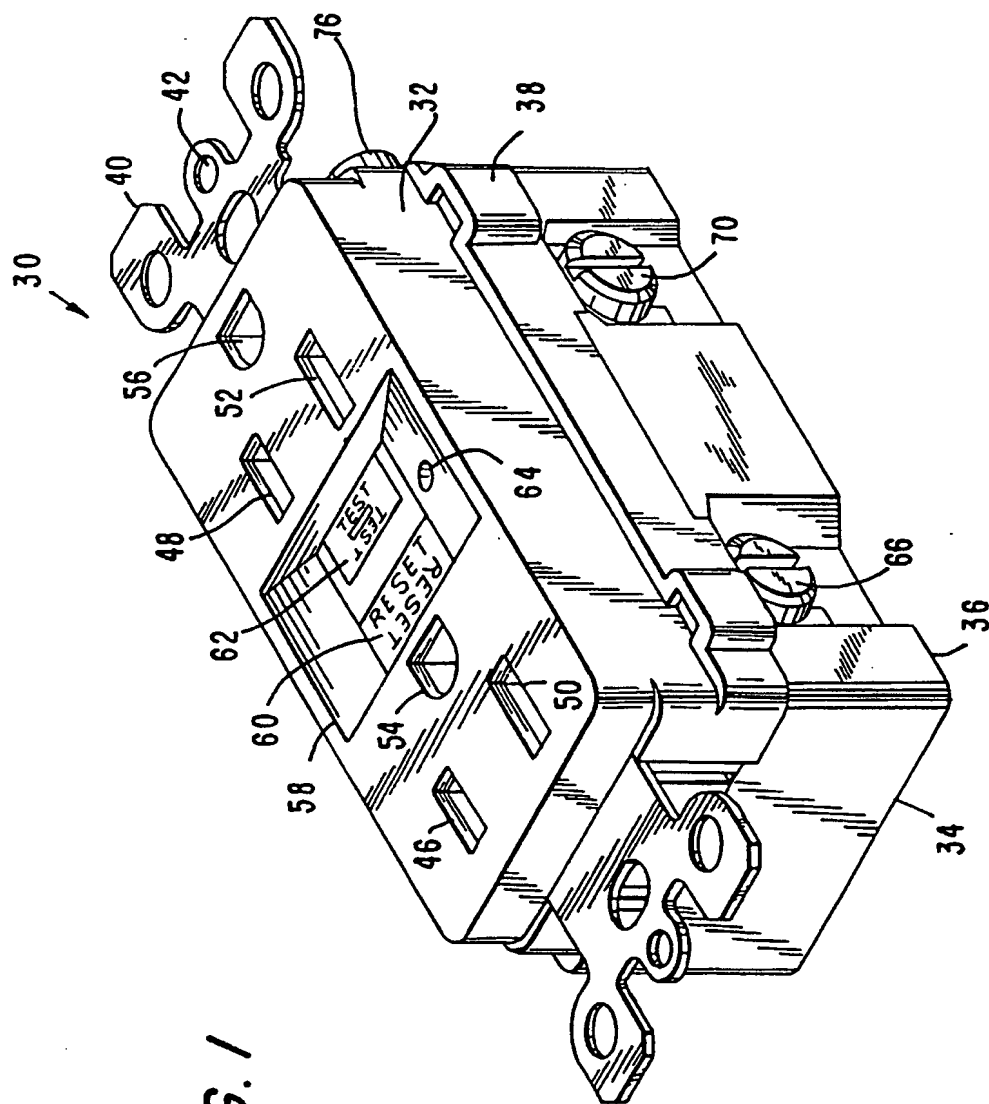


FIG. 1

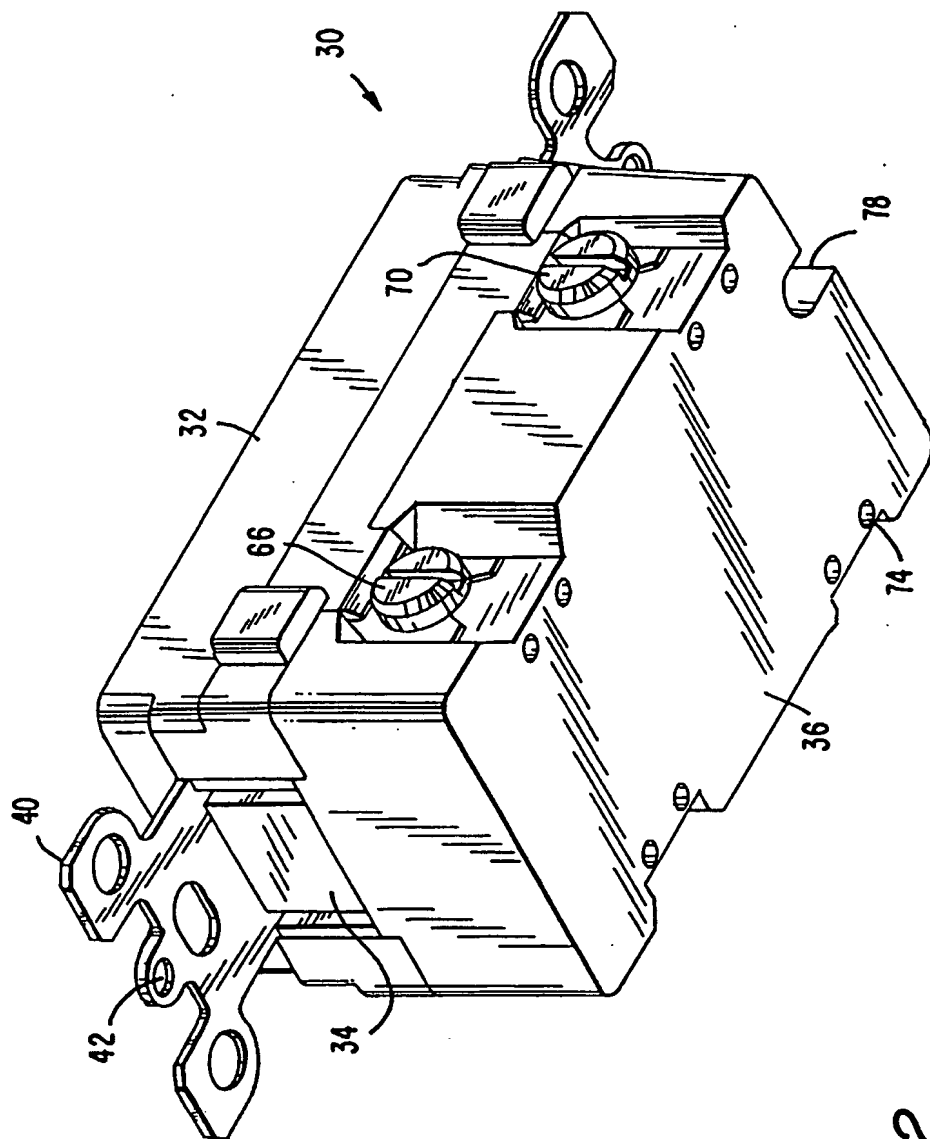
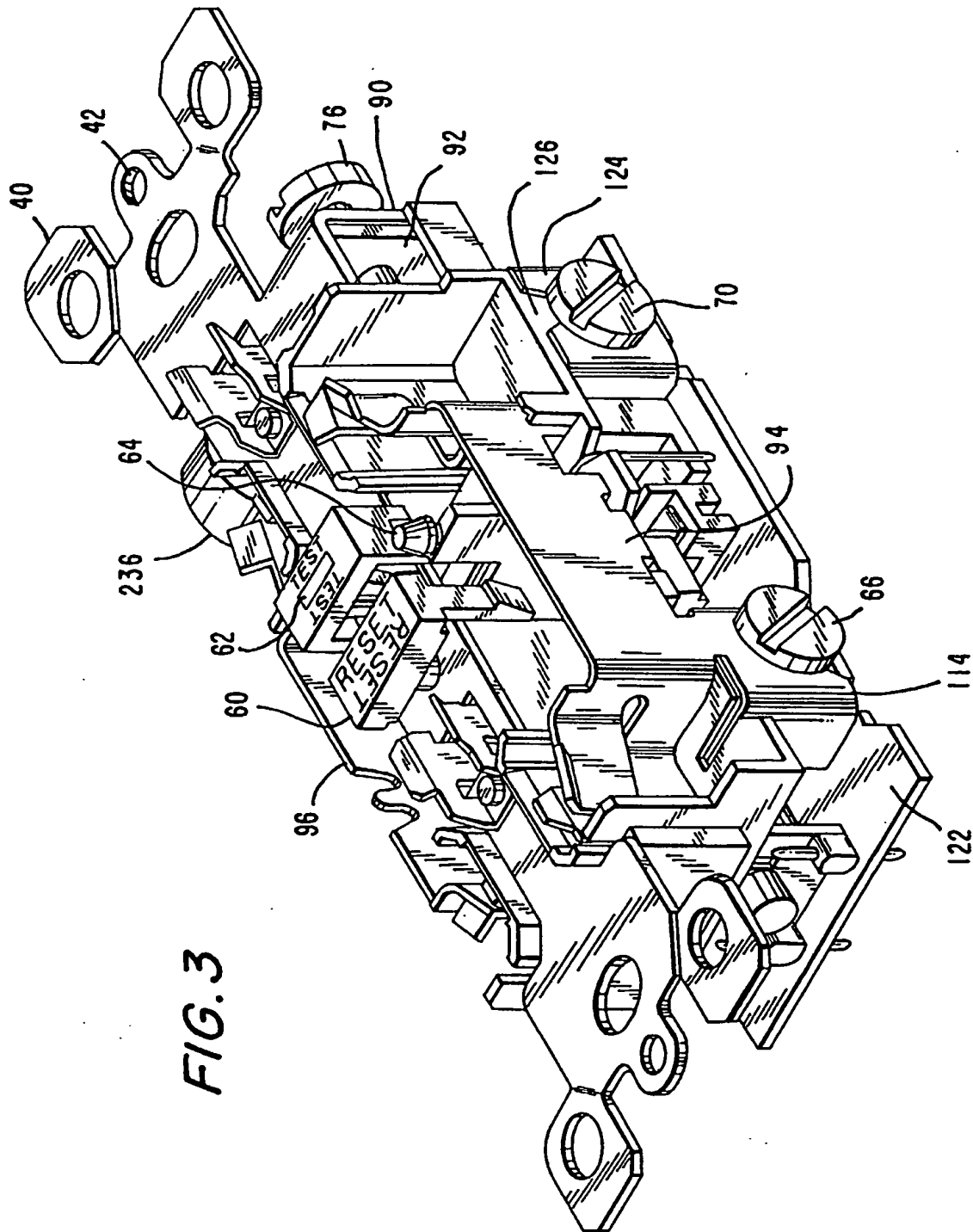
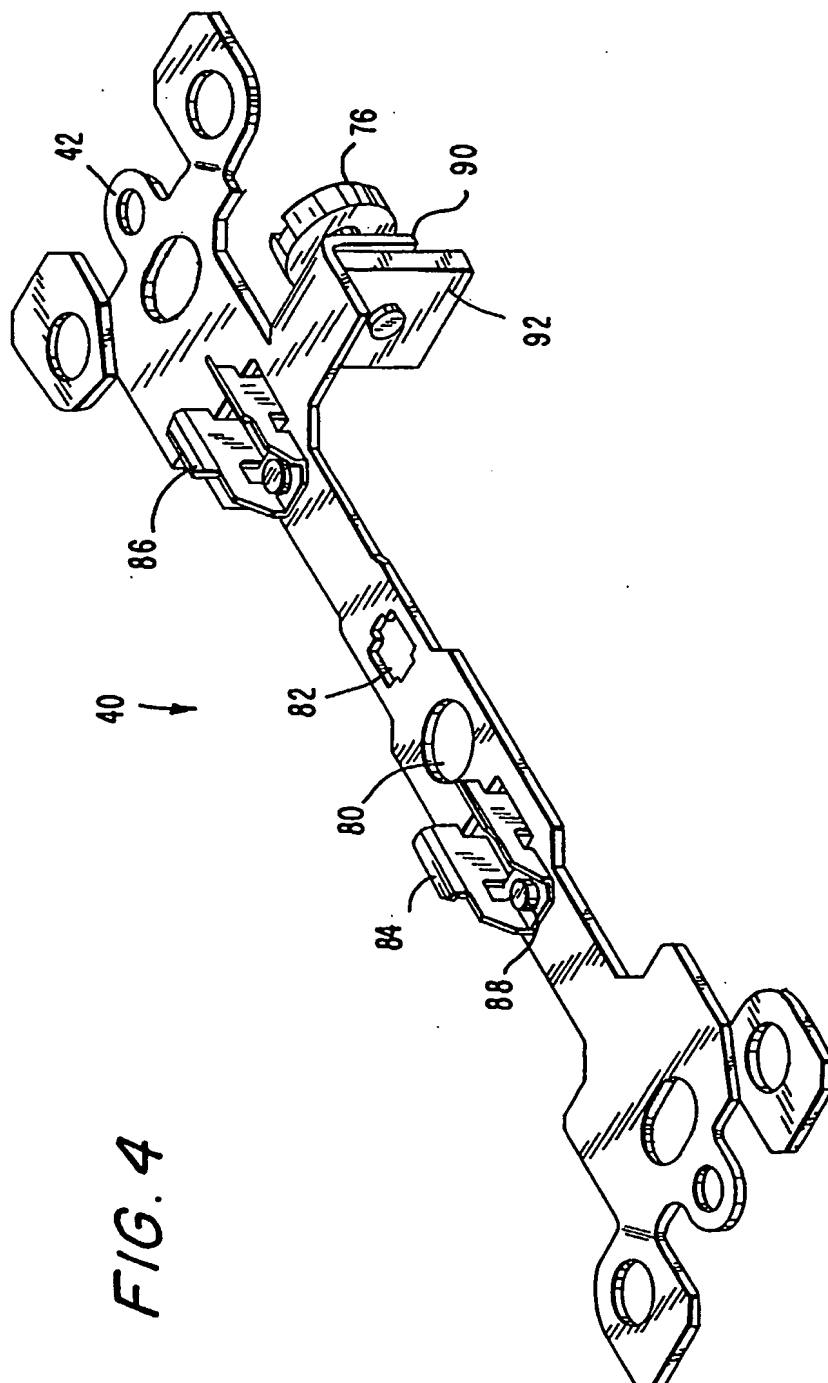
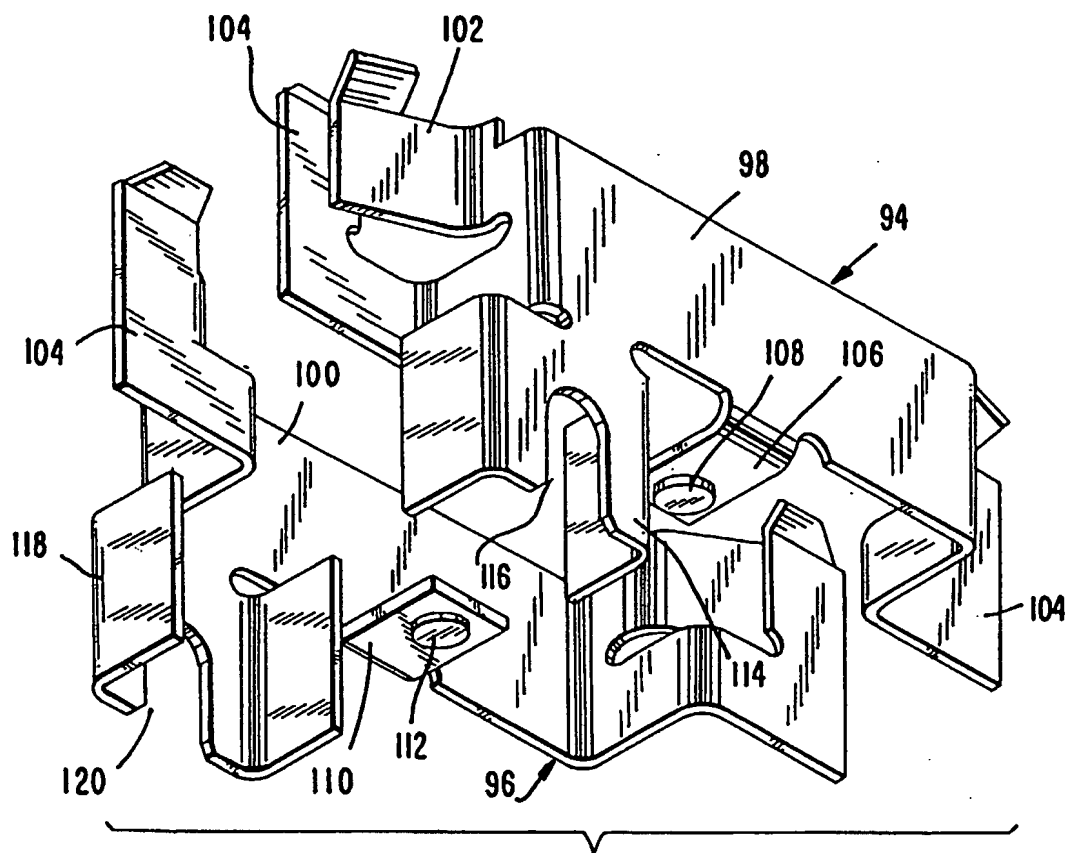


FIG. 2





**FIG. 5**

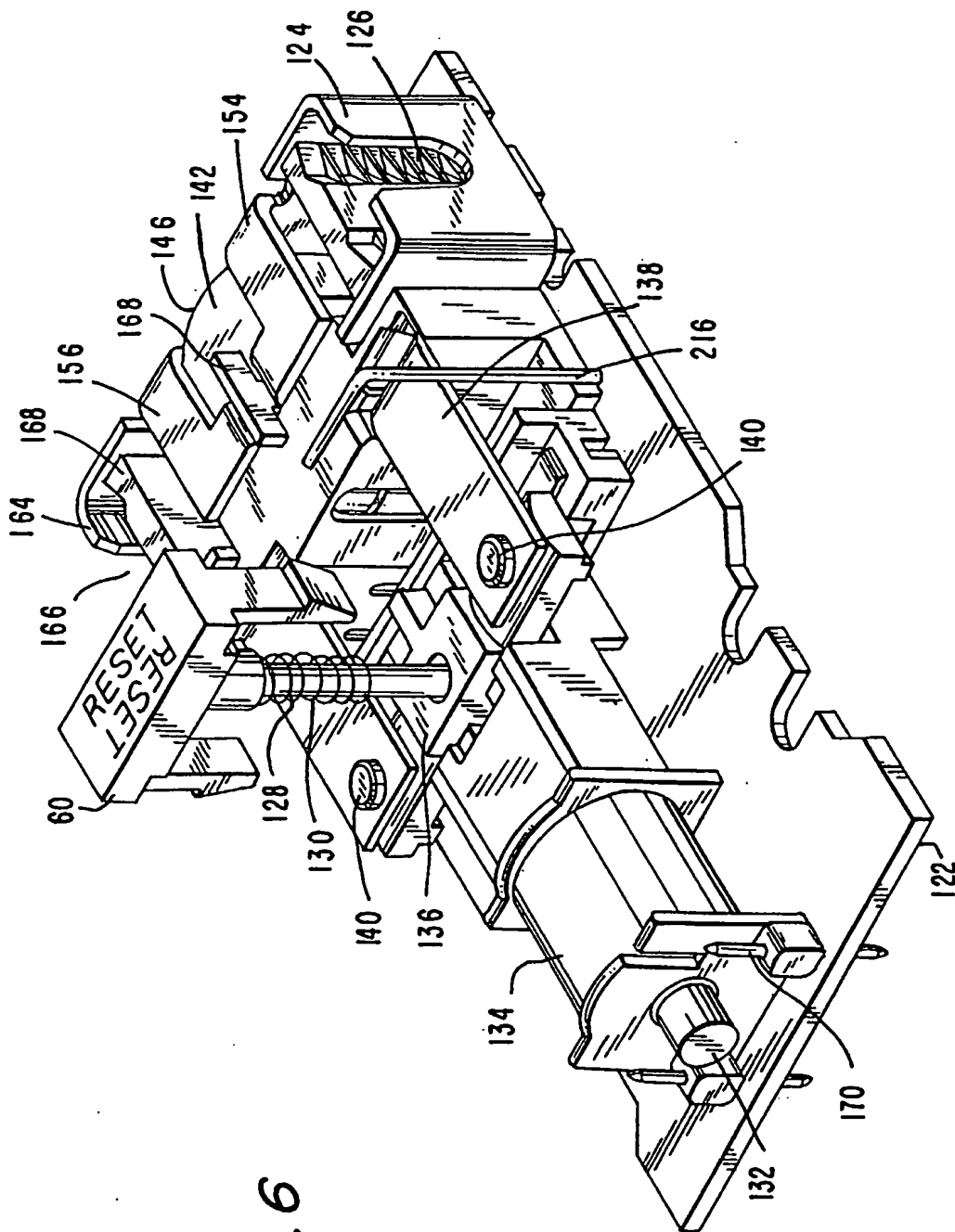


FIG. 6

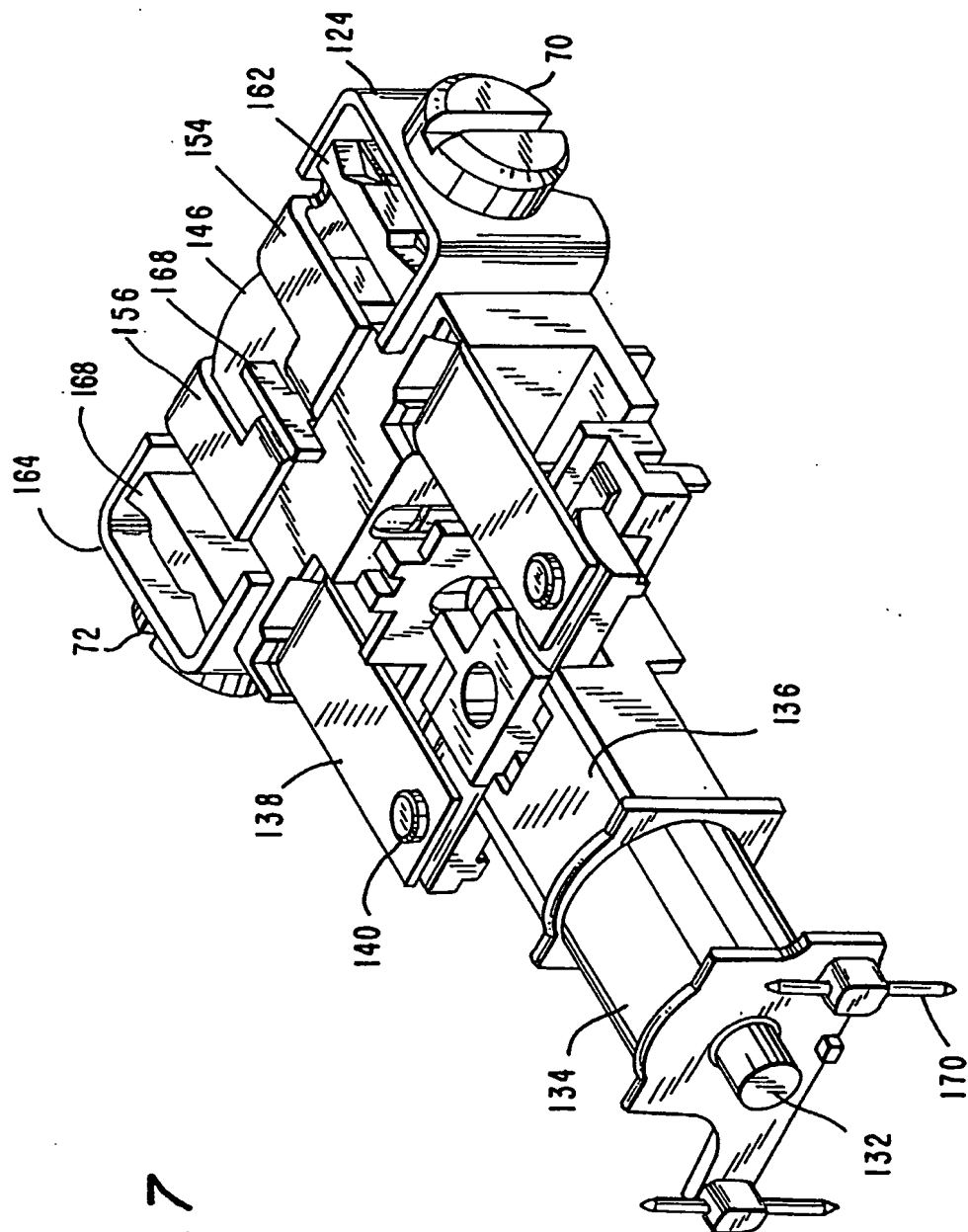
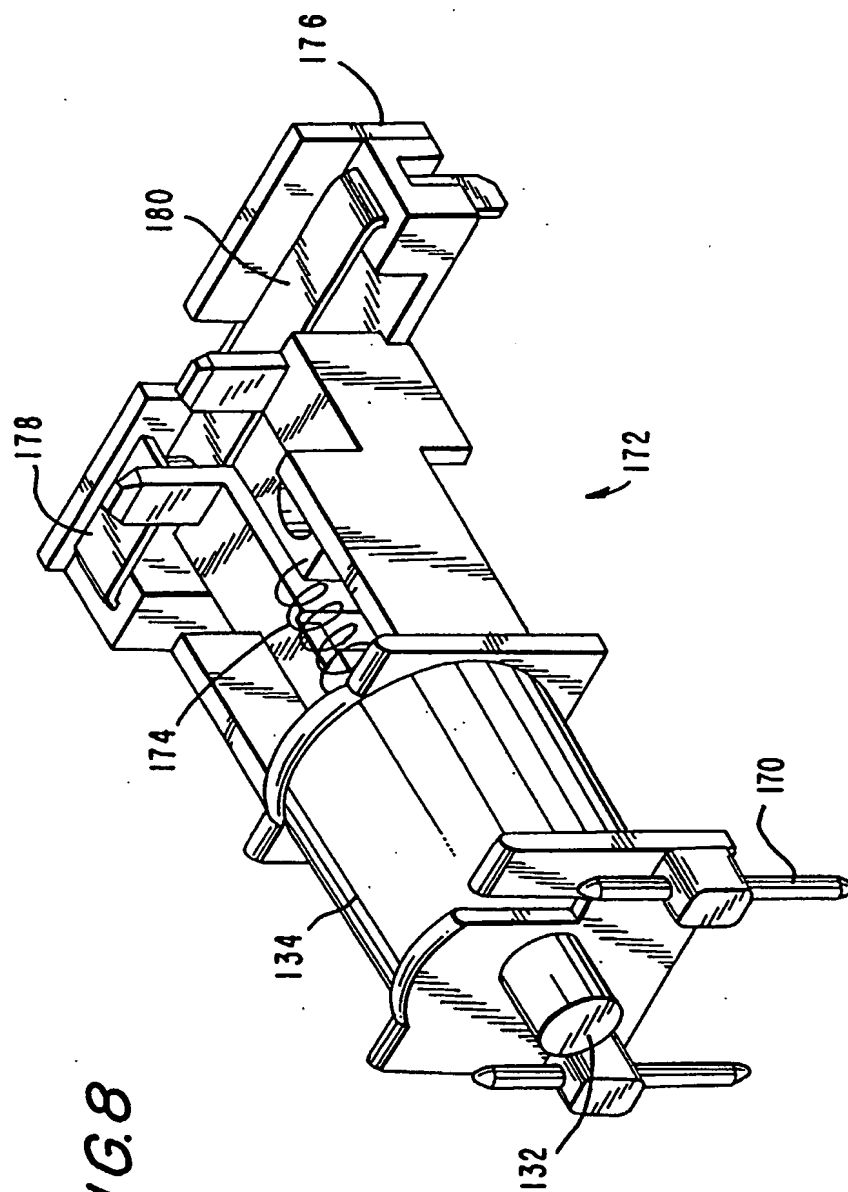
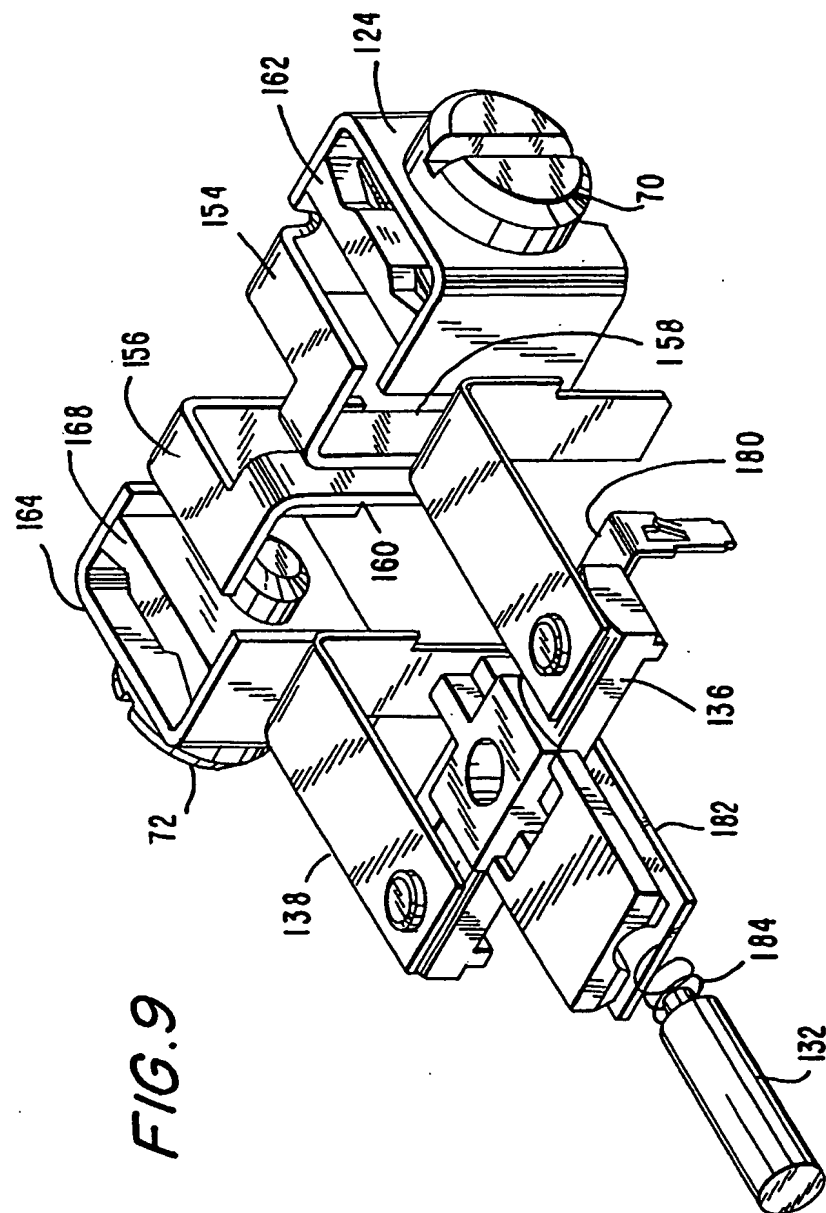
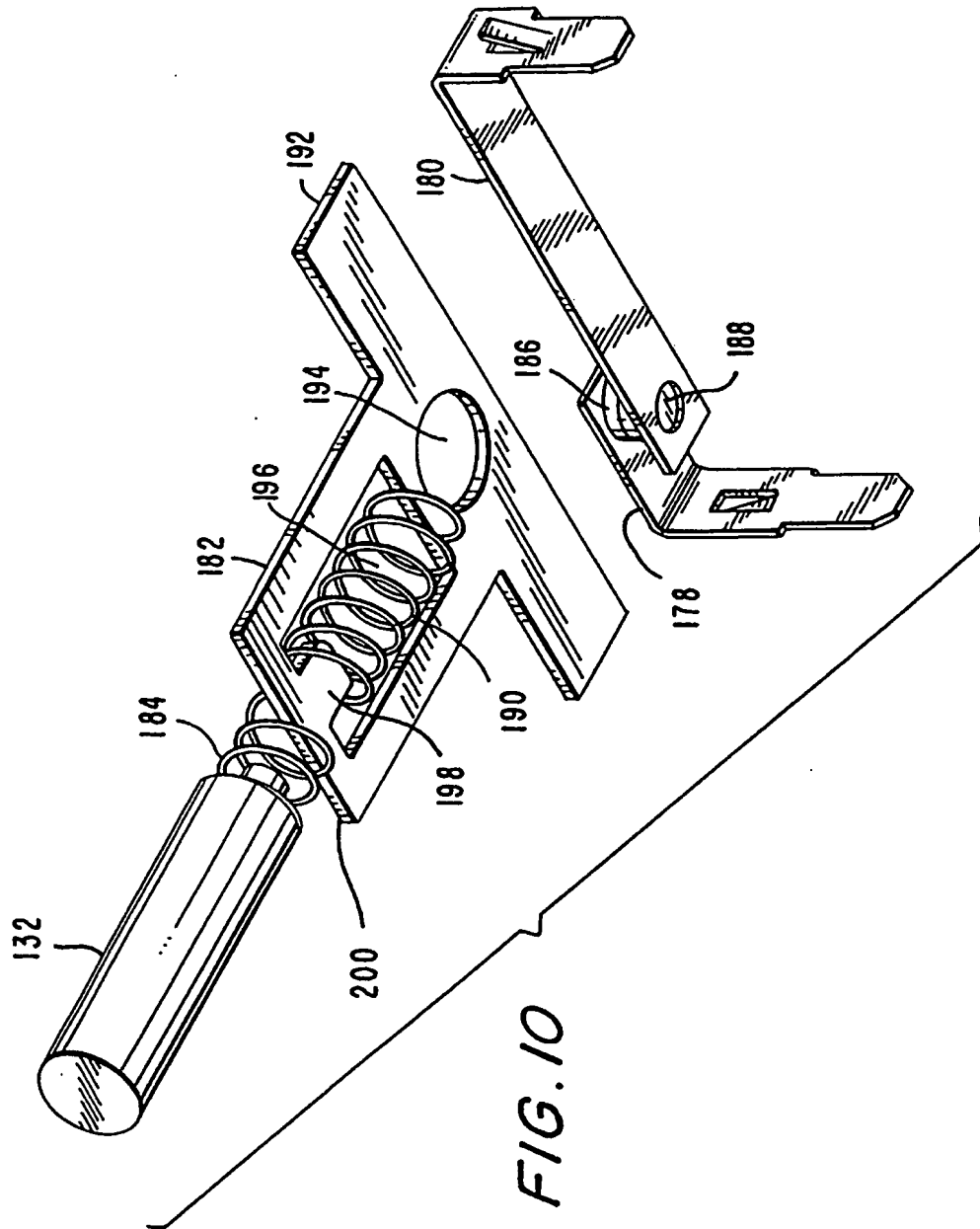


FIG. 7







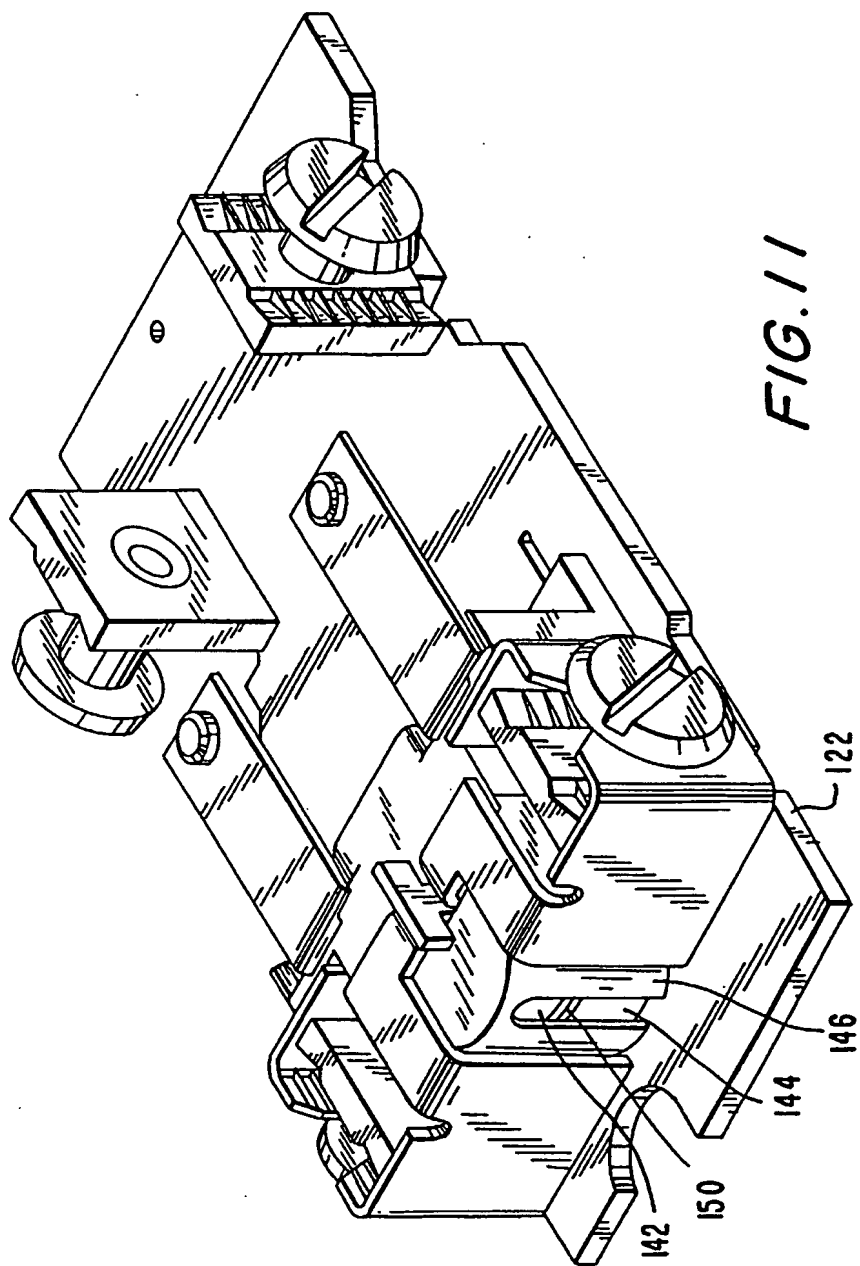


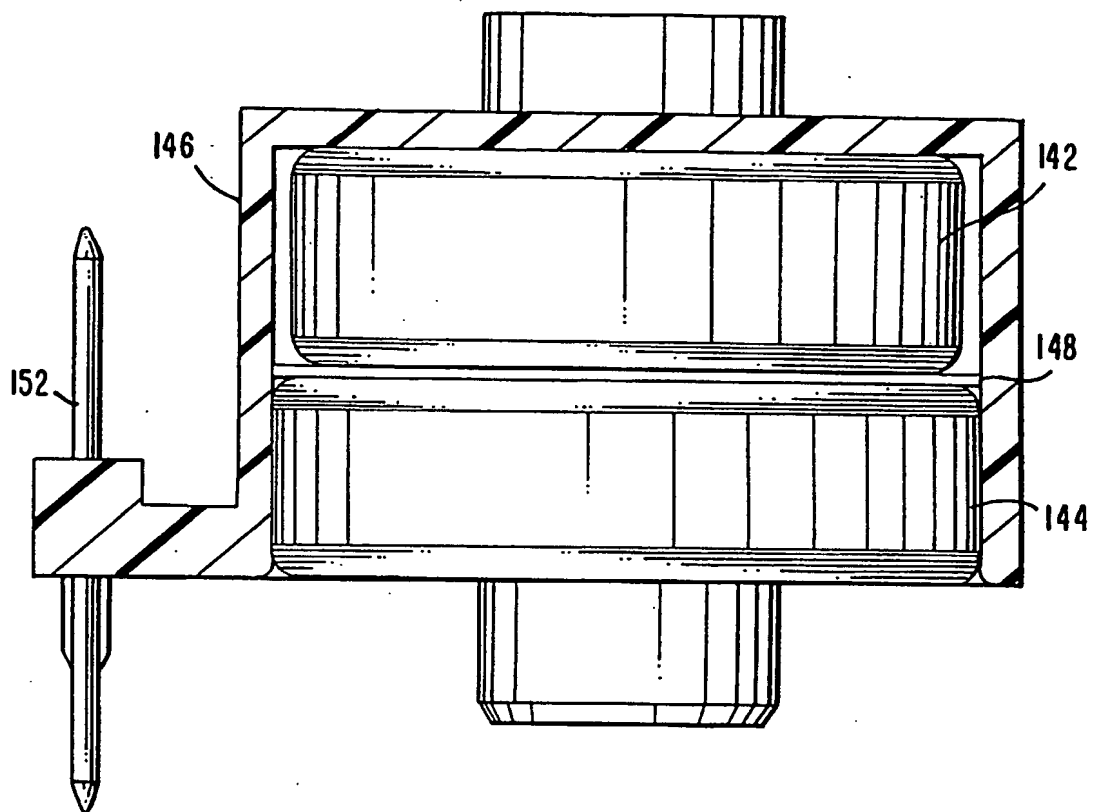
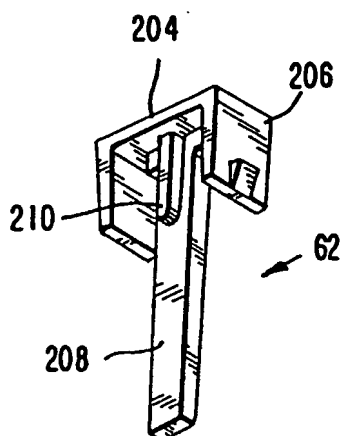
FIG. 12*FIG. 13*

FIG. 14

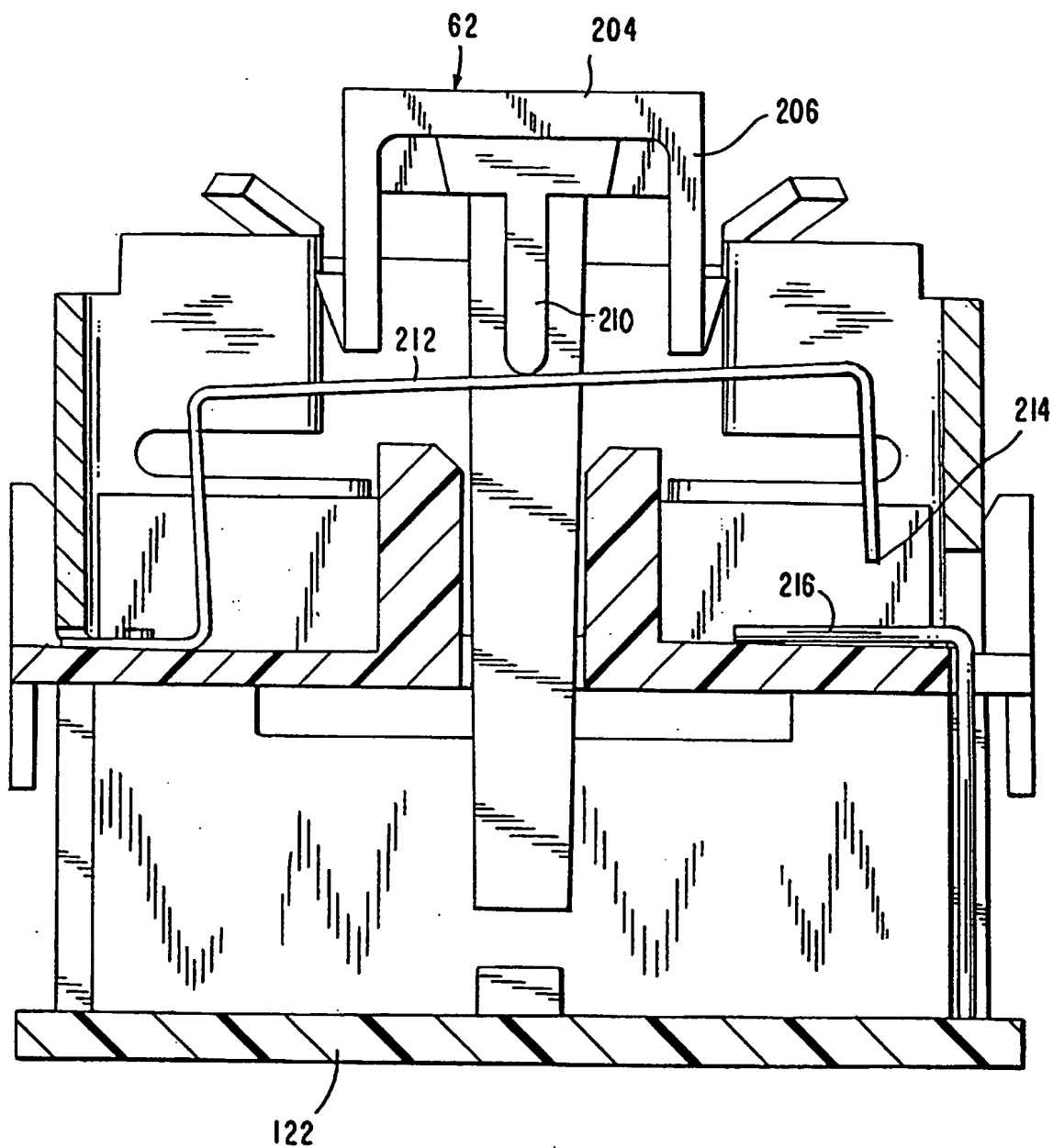
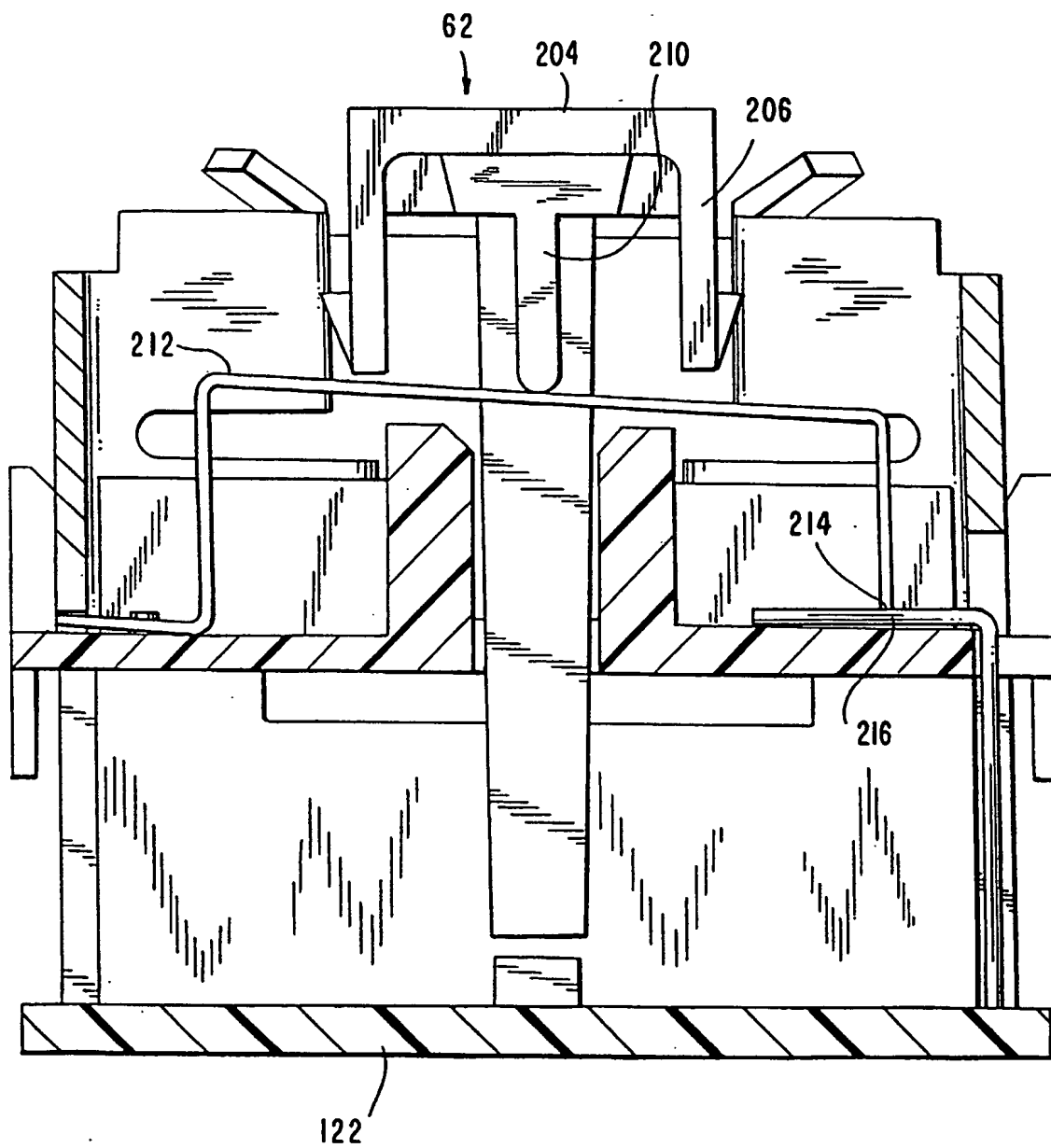


FIG. 15

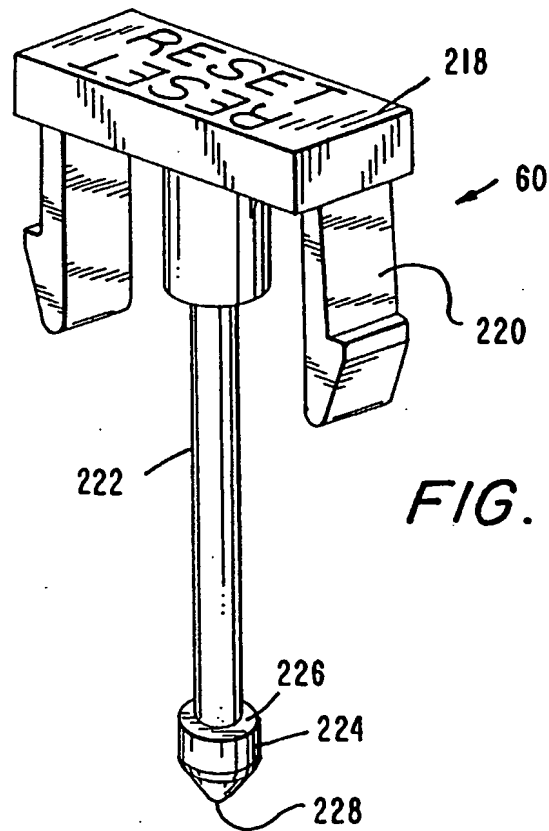
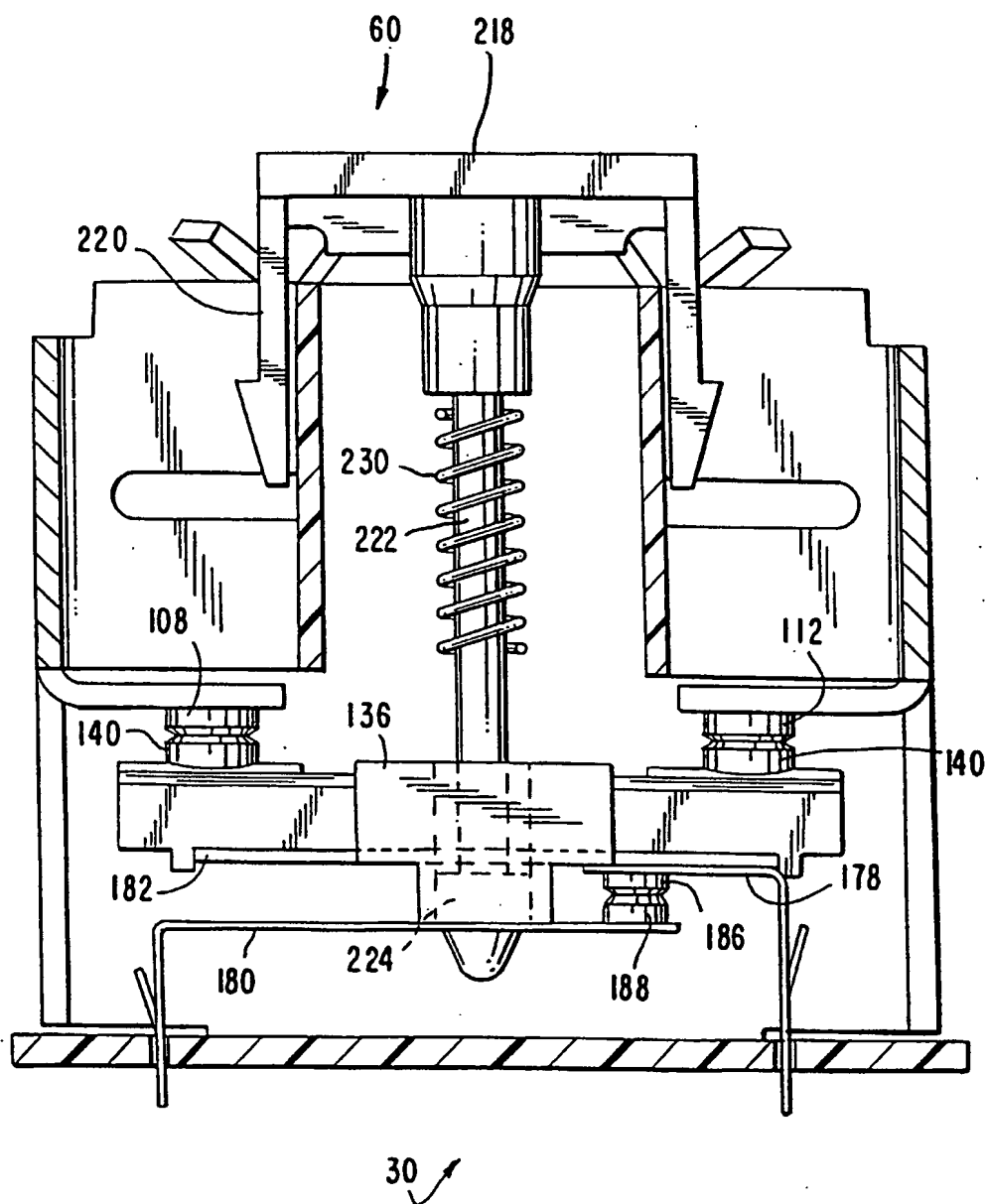


FIG. 16

MODE	LED INDICATOR			PIEZO BEEPER
	GREEN	RED	AMBER	
SUPERVISORY	GREEN	RED	AMBER	PIEZO BEEPER
25 DAYS	SLOW	NA	NA	OFF
30 DAYS	FAST	NA	NA	OFF
TRIP-EXTERNAL FAULT	NA	NA	FAST	OFF
FAULT IN GFCI	NA	NA	FAST	ON
POWER ON RESET	NA	FAST	NA	ON
	NA	NA	FAST	OFF

FIG. 21

FIG. 17



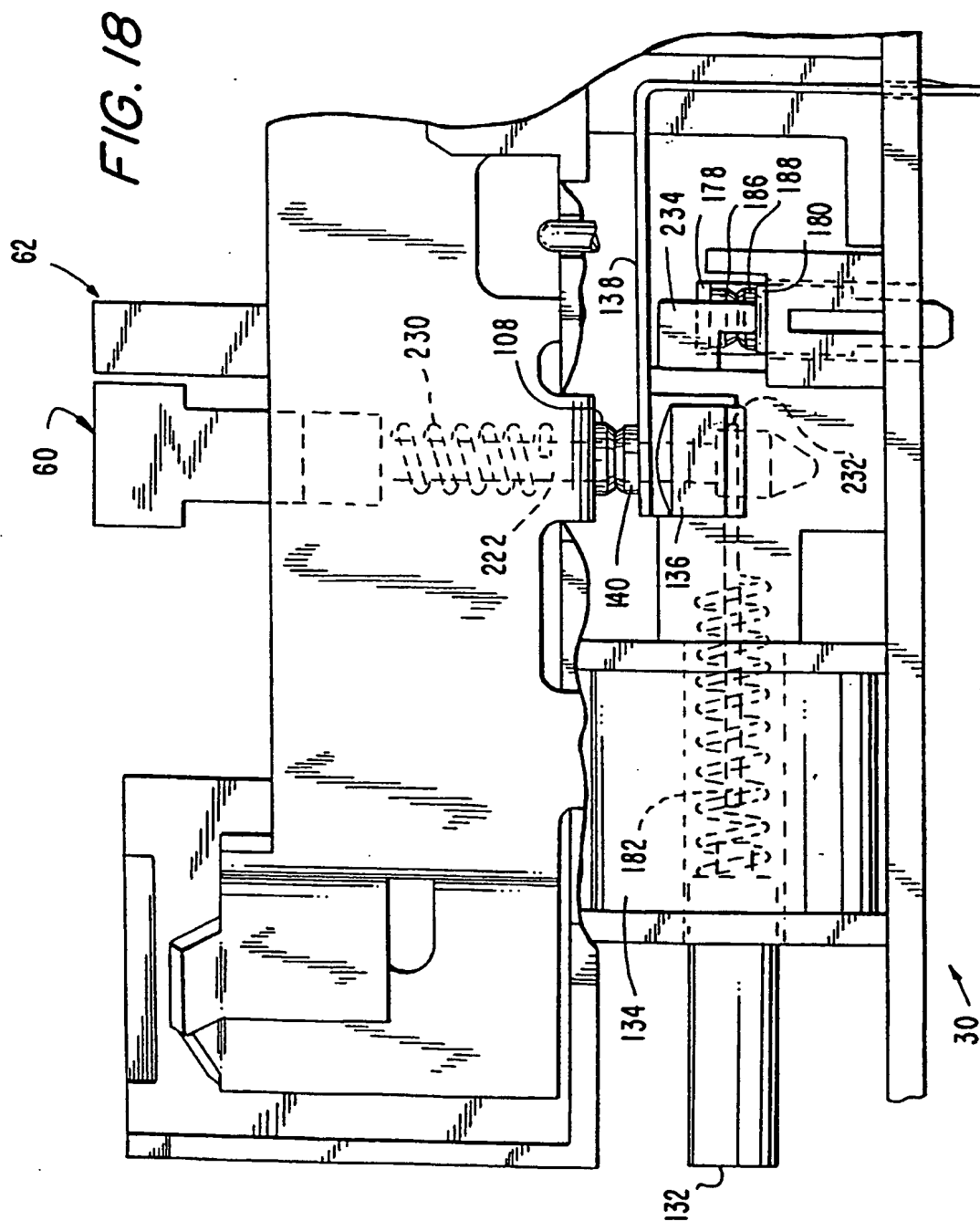
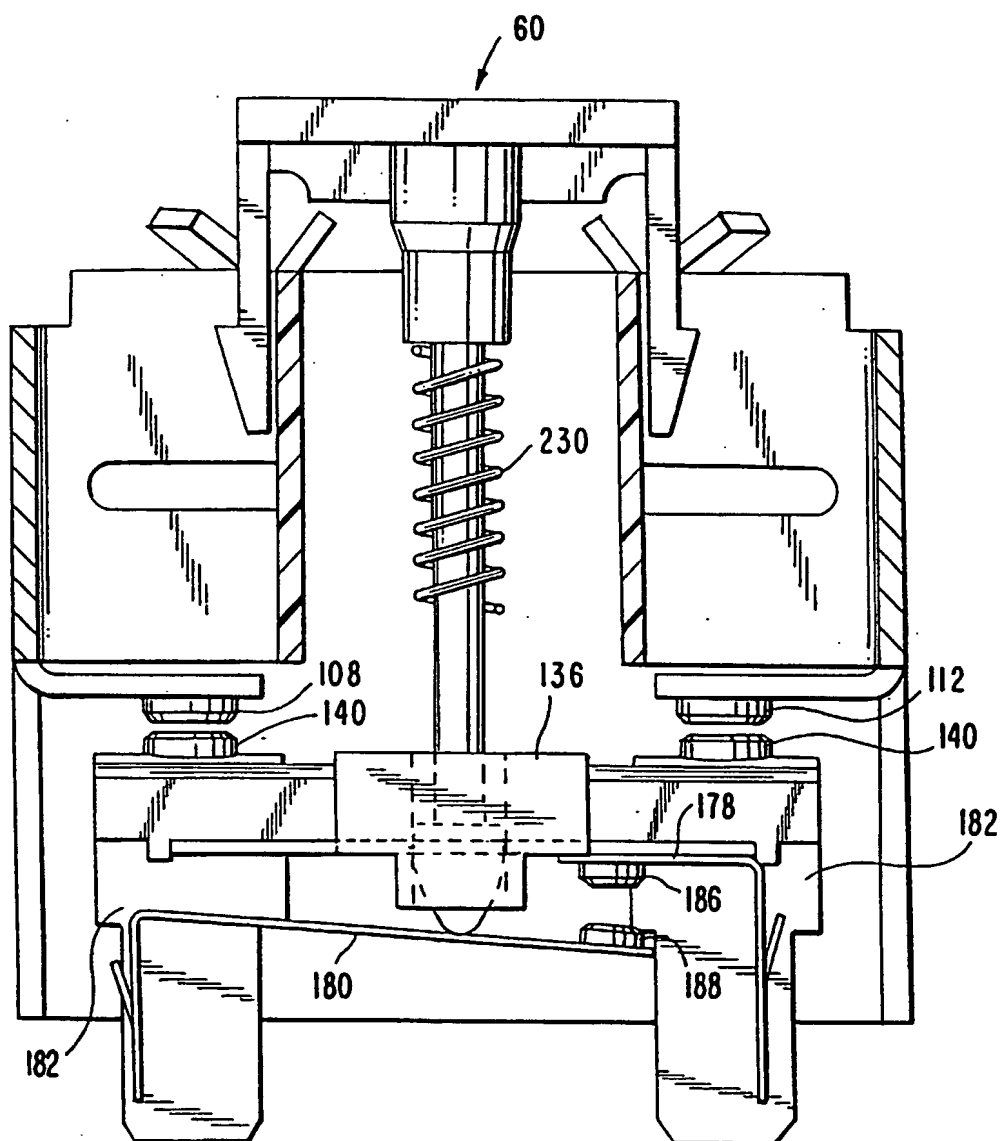
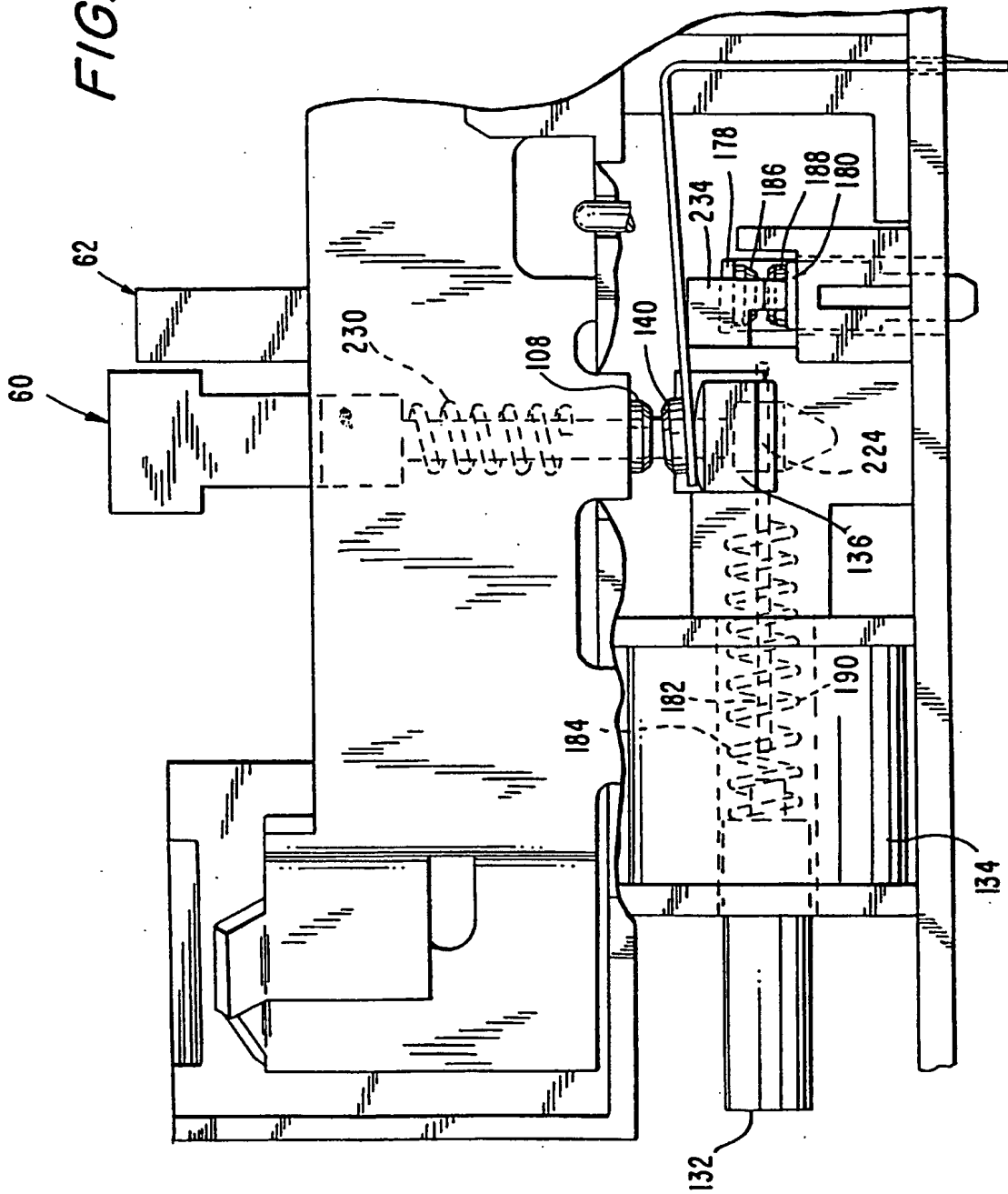


FIG. 19



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FIG. 20



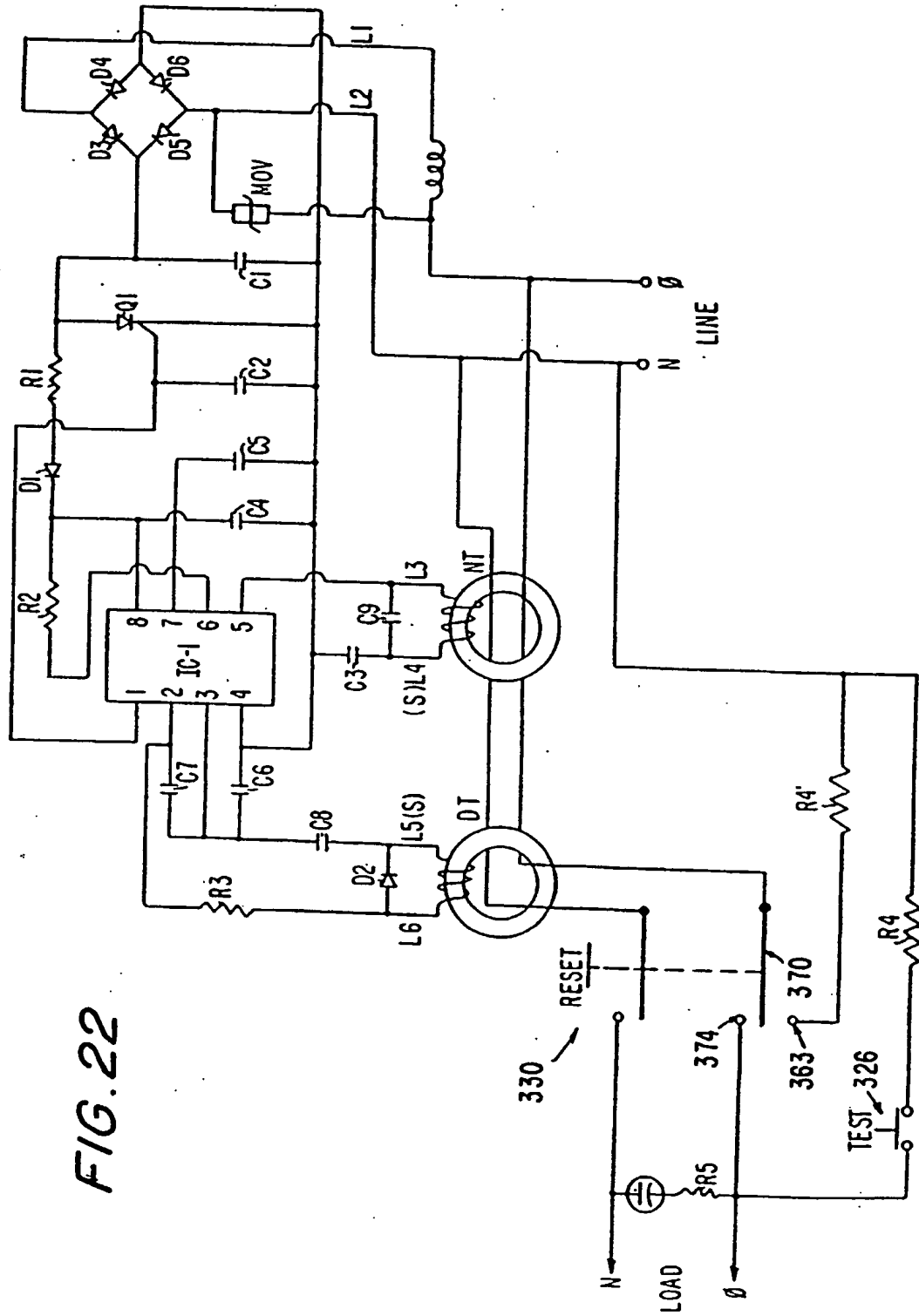
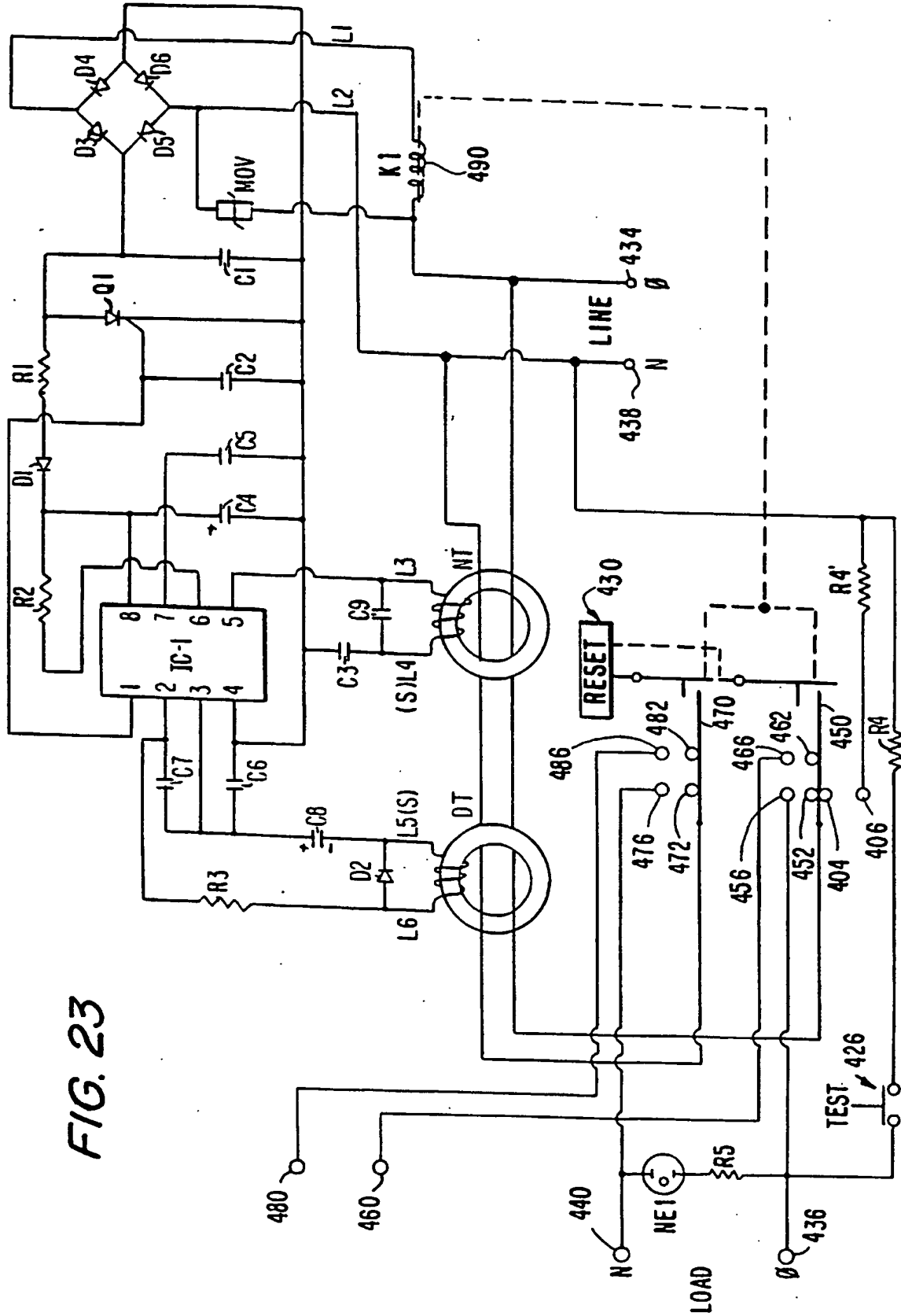
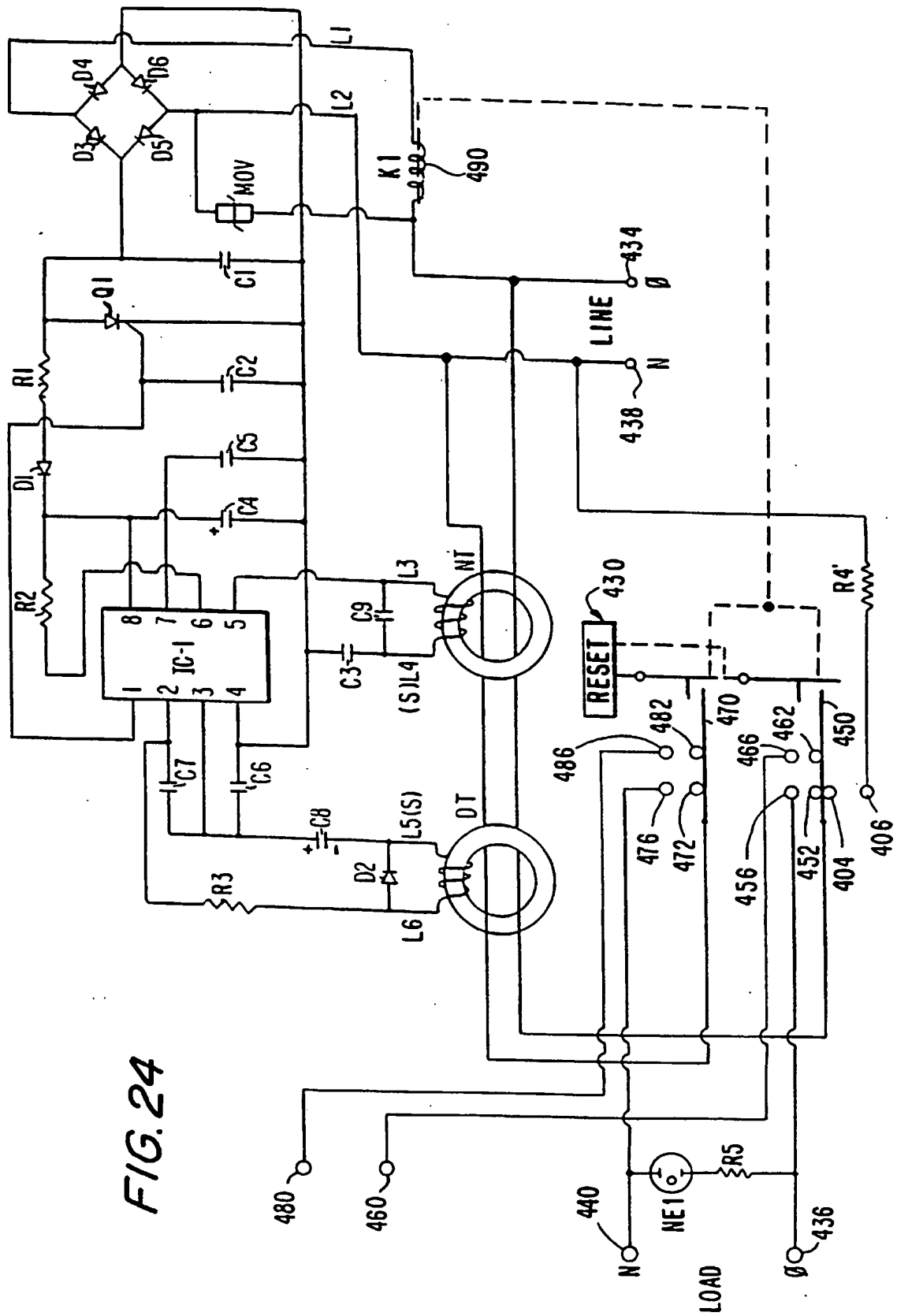
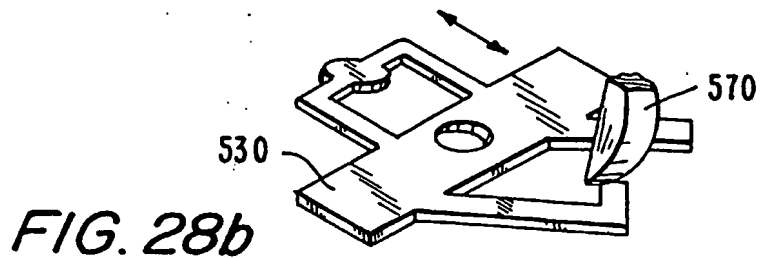
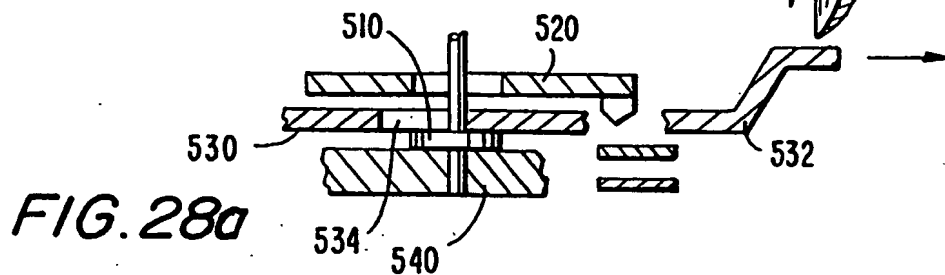
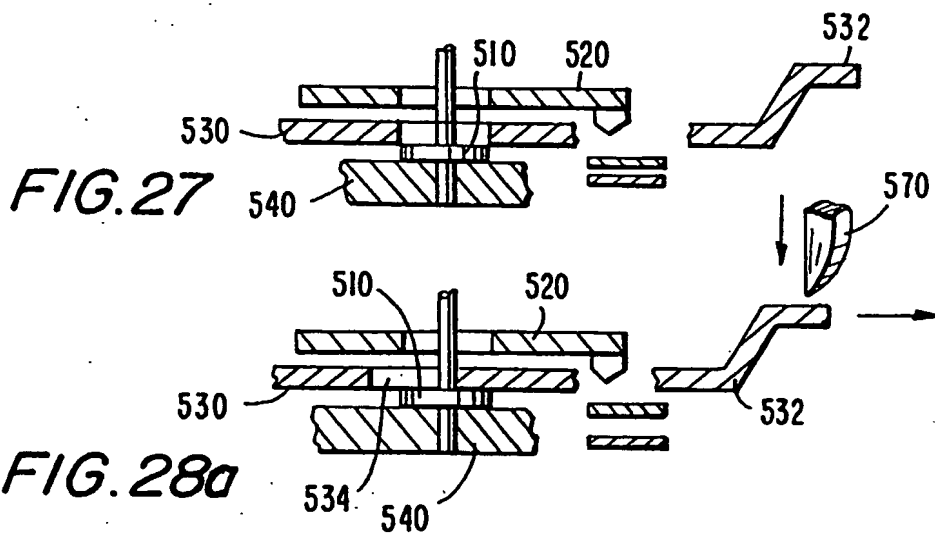
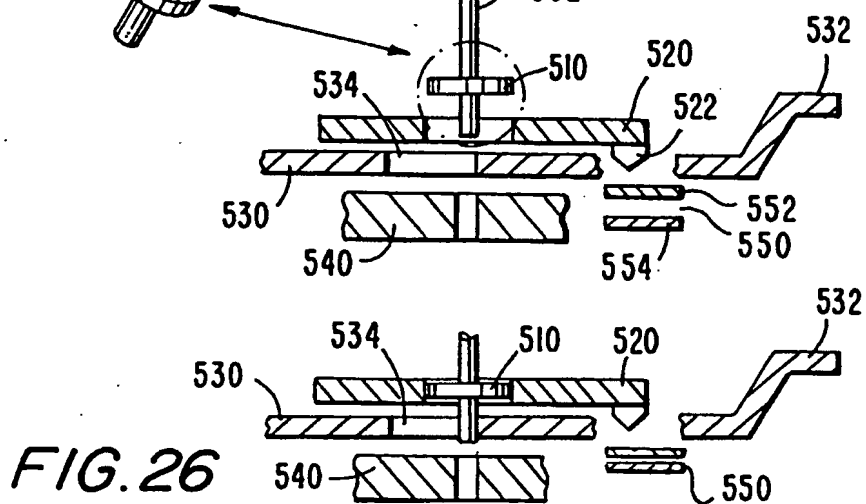
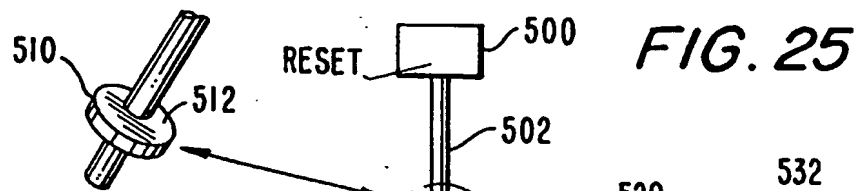


FIG. 22

FIG. 23







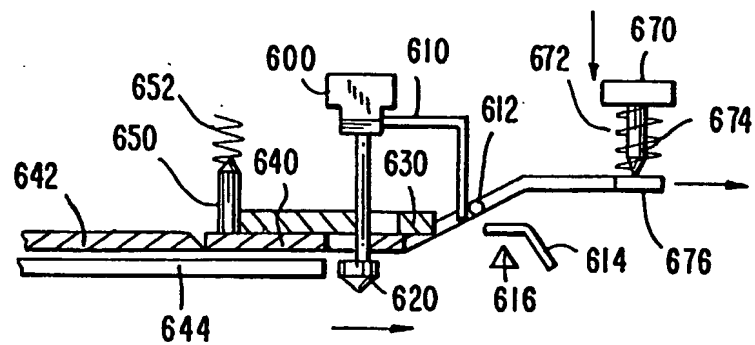
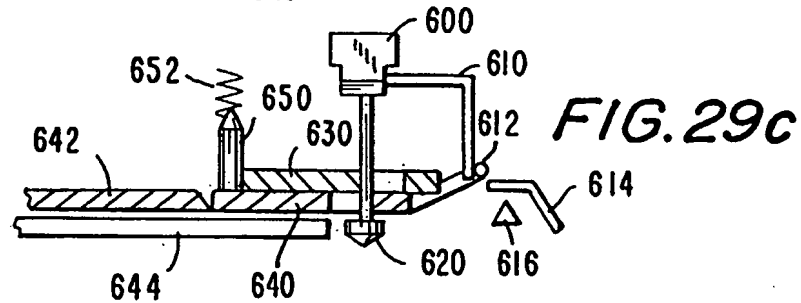
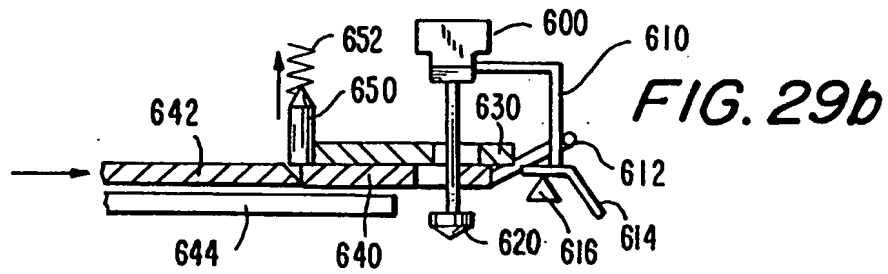
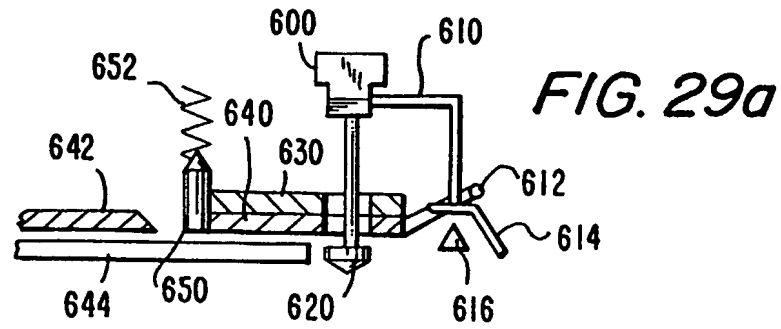


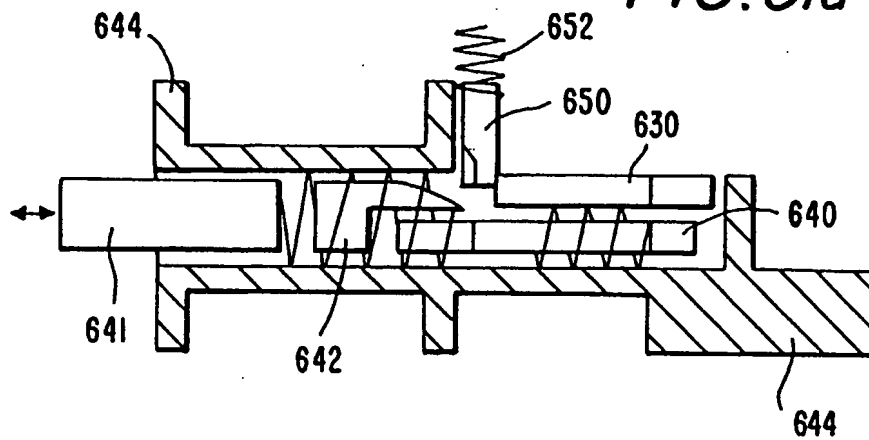
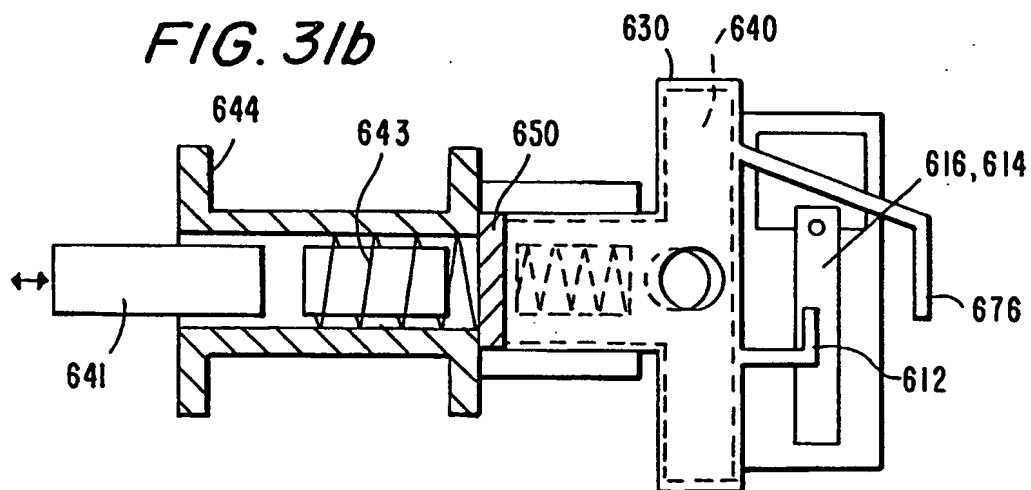
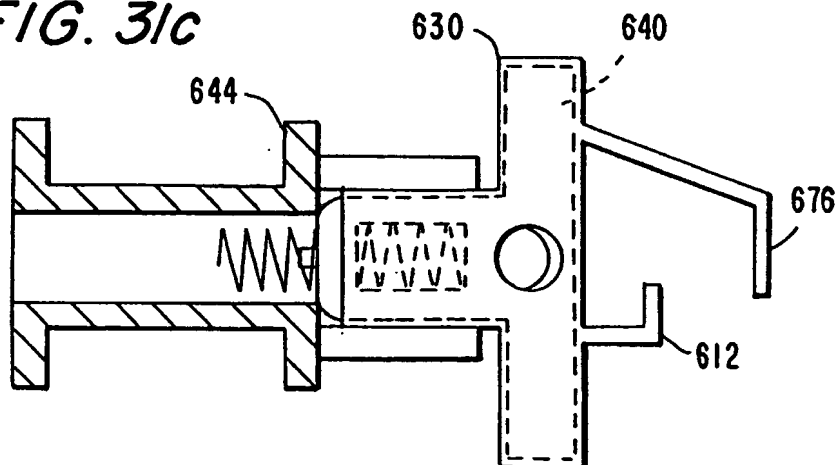
FIG. 3la*FIG. 3lb**FIG. 3lc*

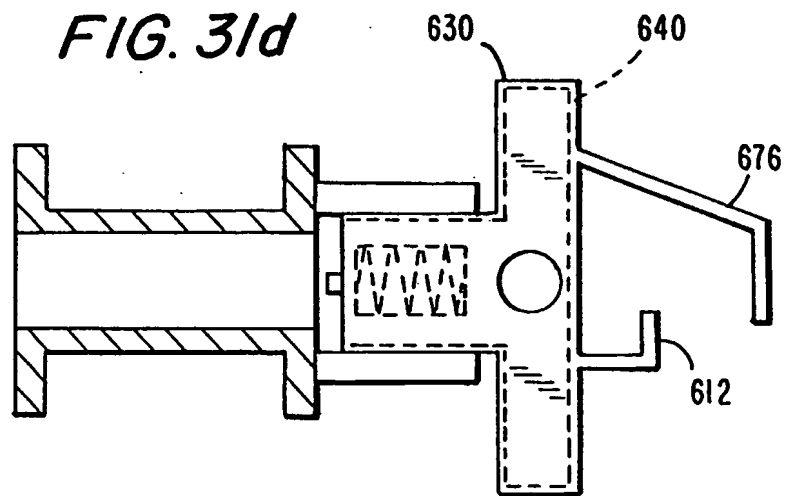
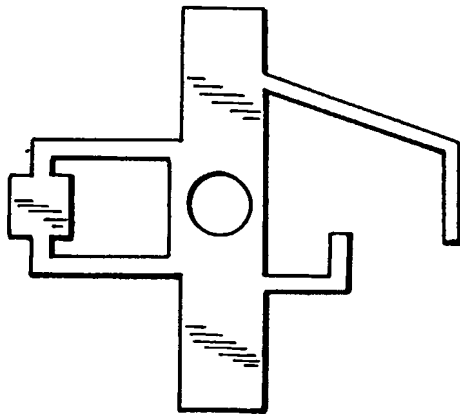
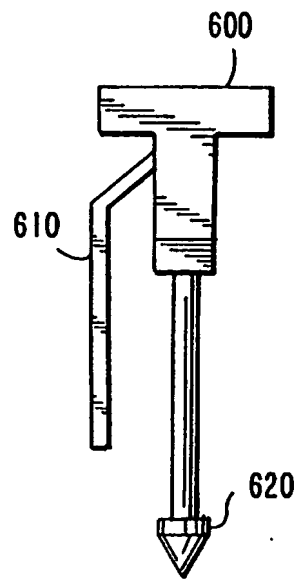
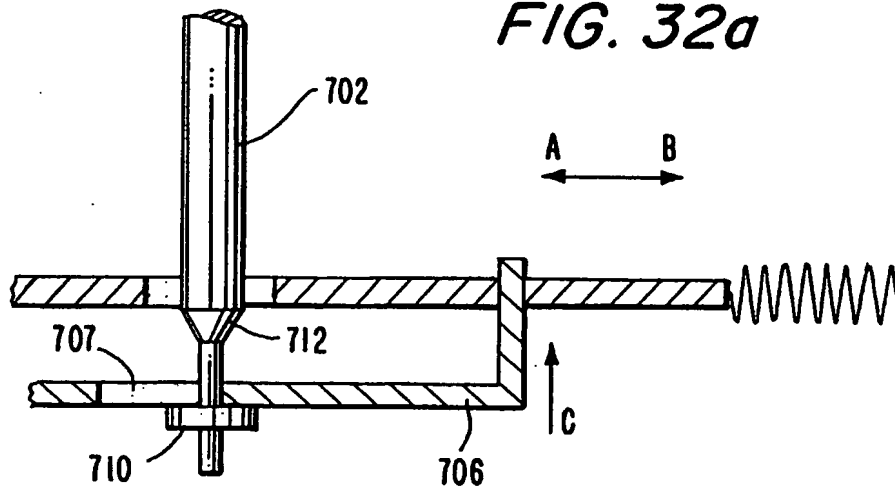
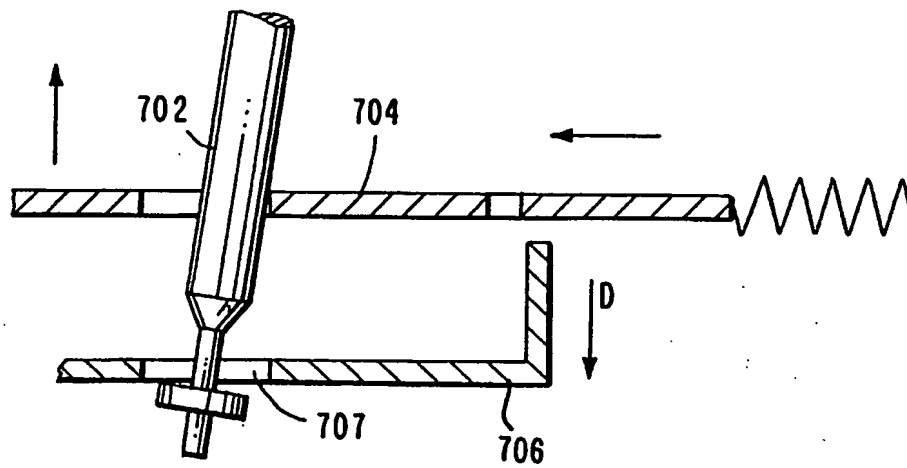
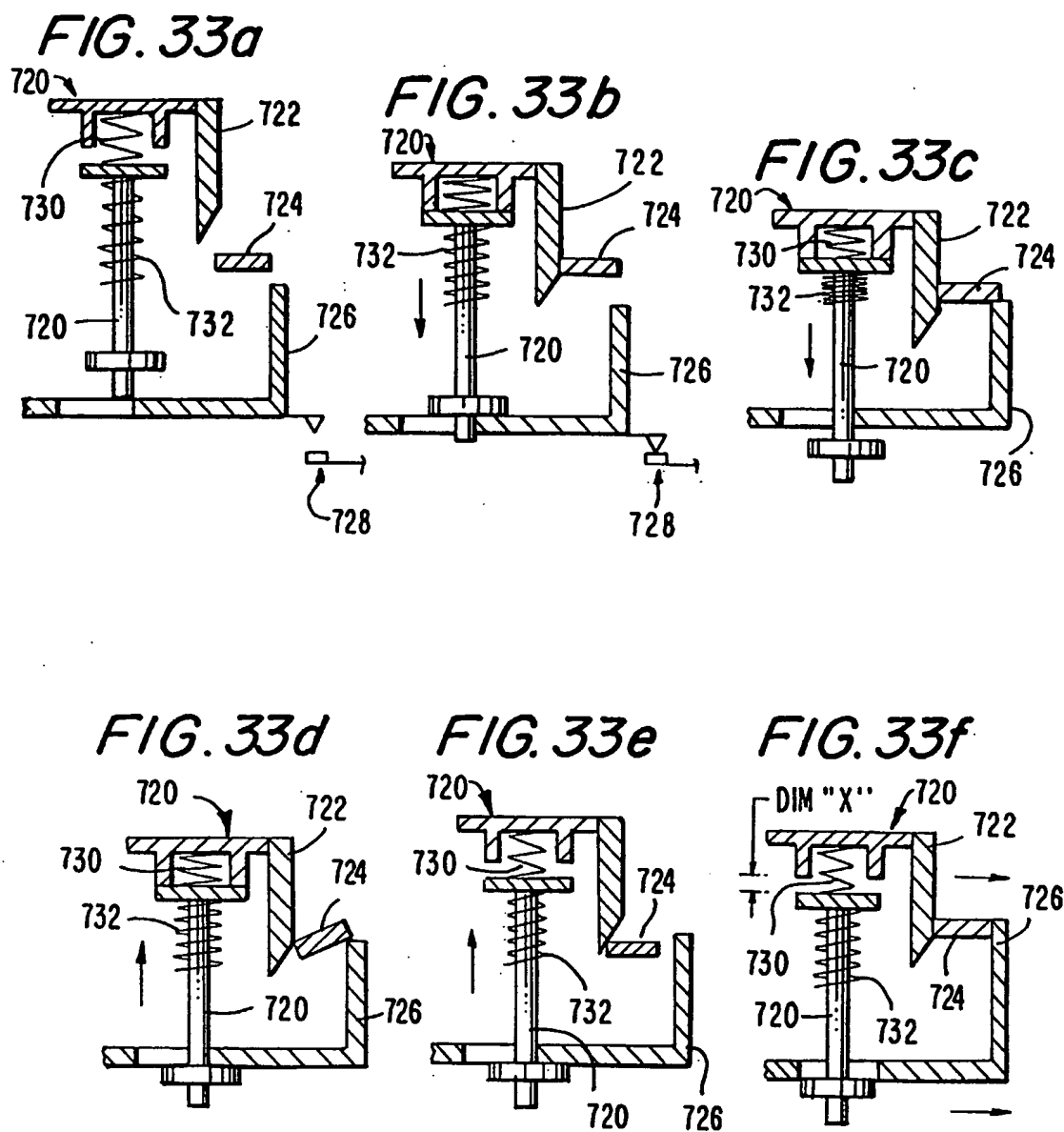
FIG. 3Id*FIG. 3Ie**FIG. 3If*

FIG. 32a*FIG. 32b*



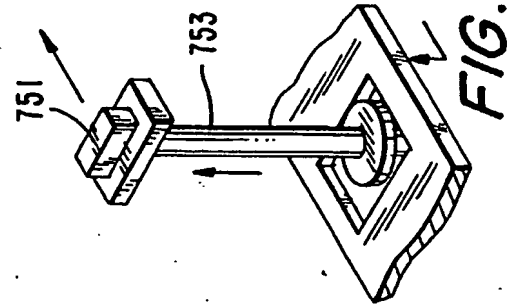
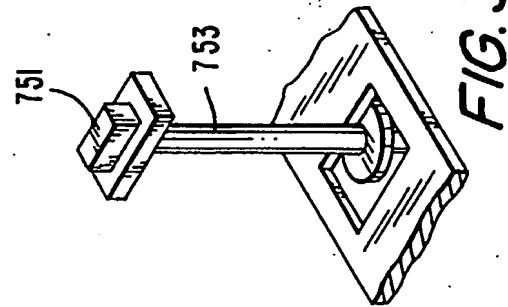
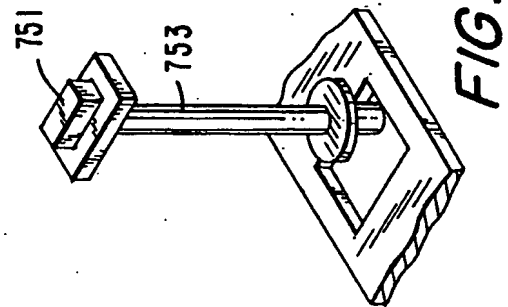
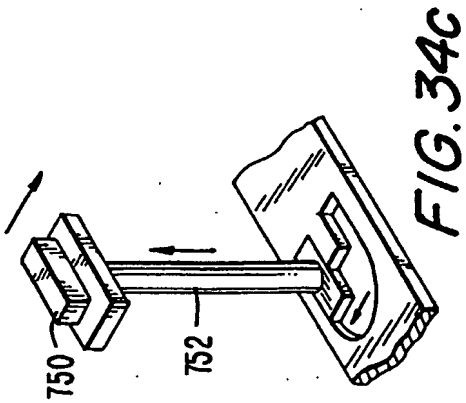
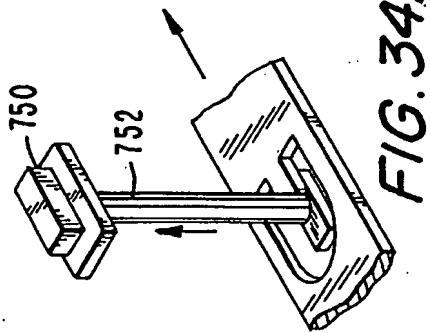
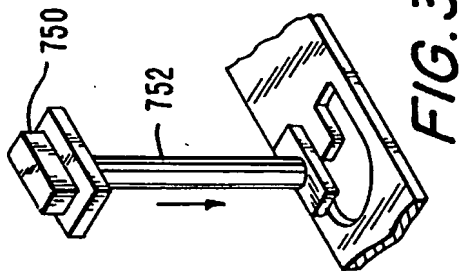


FIG. 35

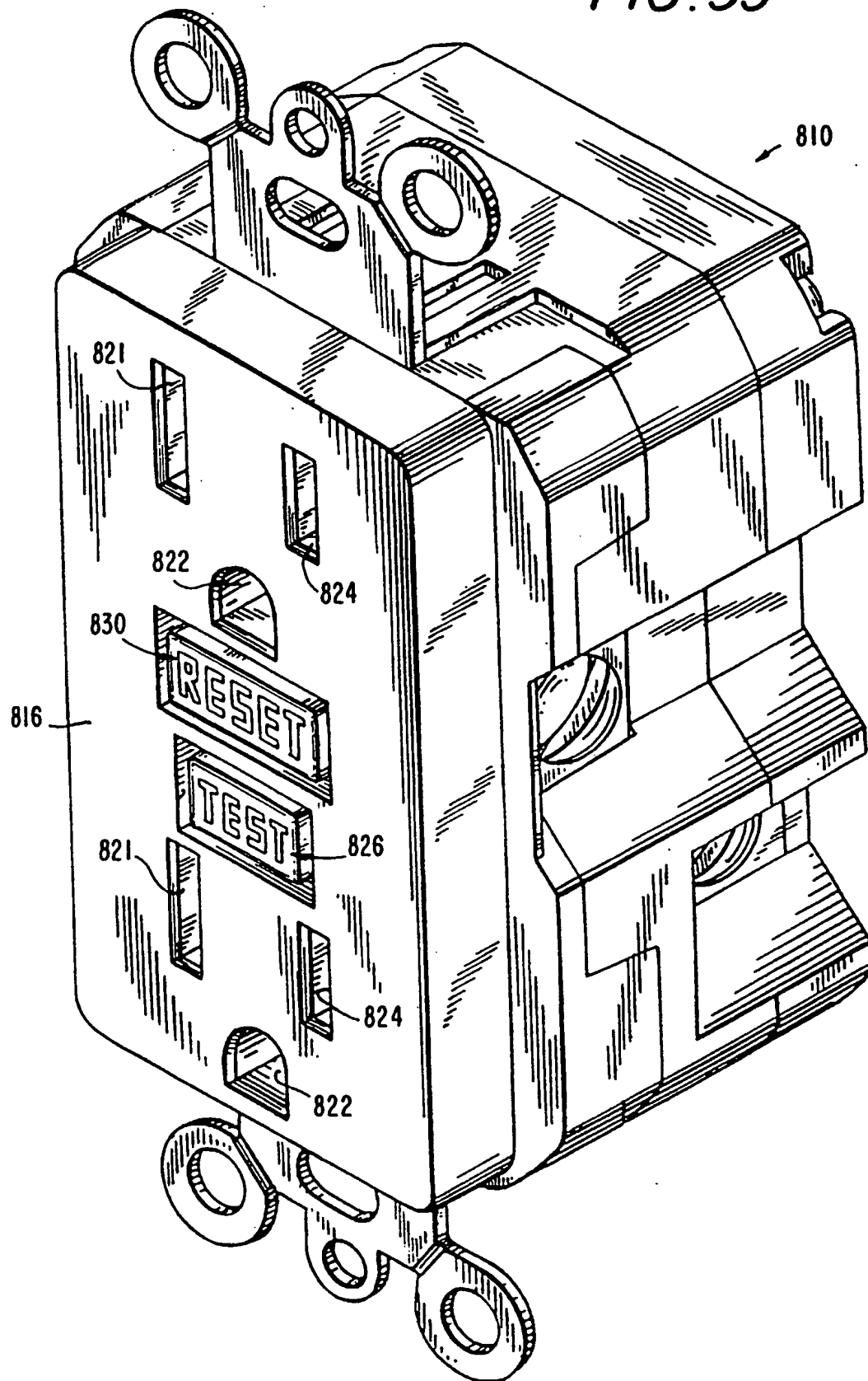


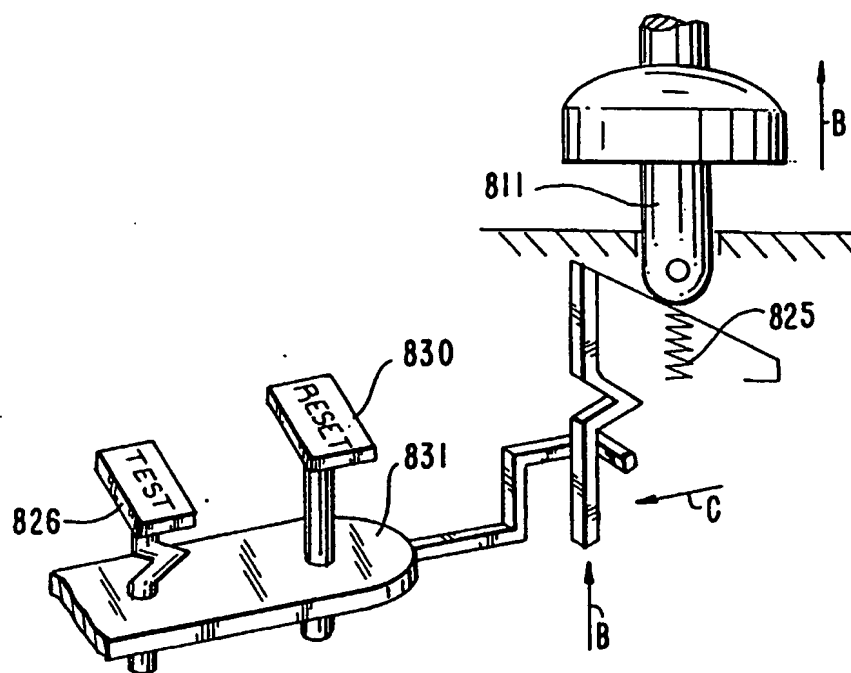
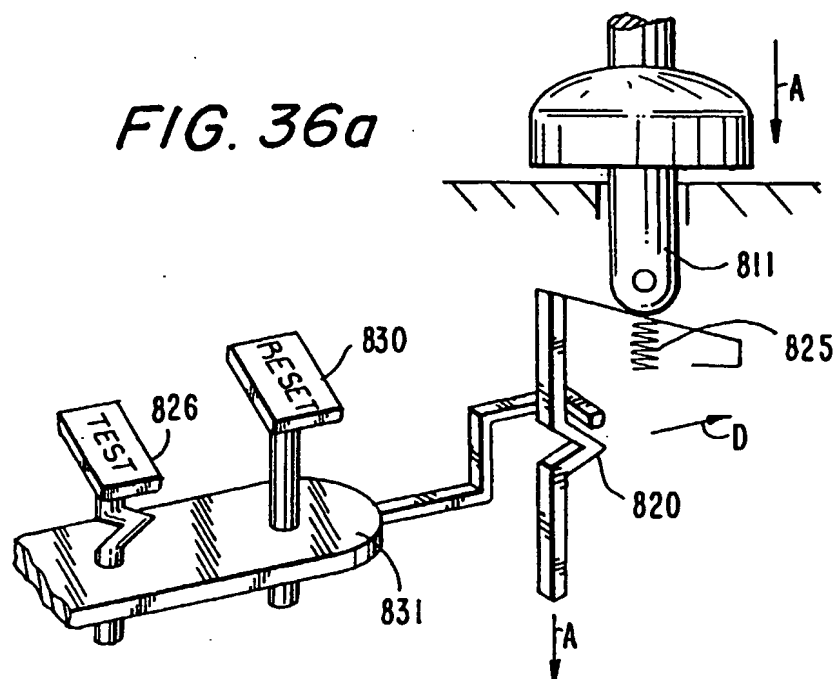
FIG. 36a*FIG. 36b*

FIG. 37

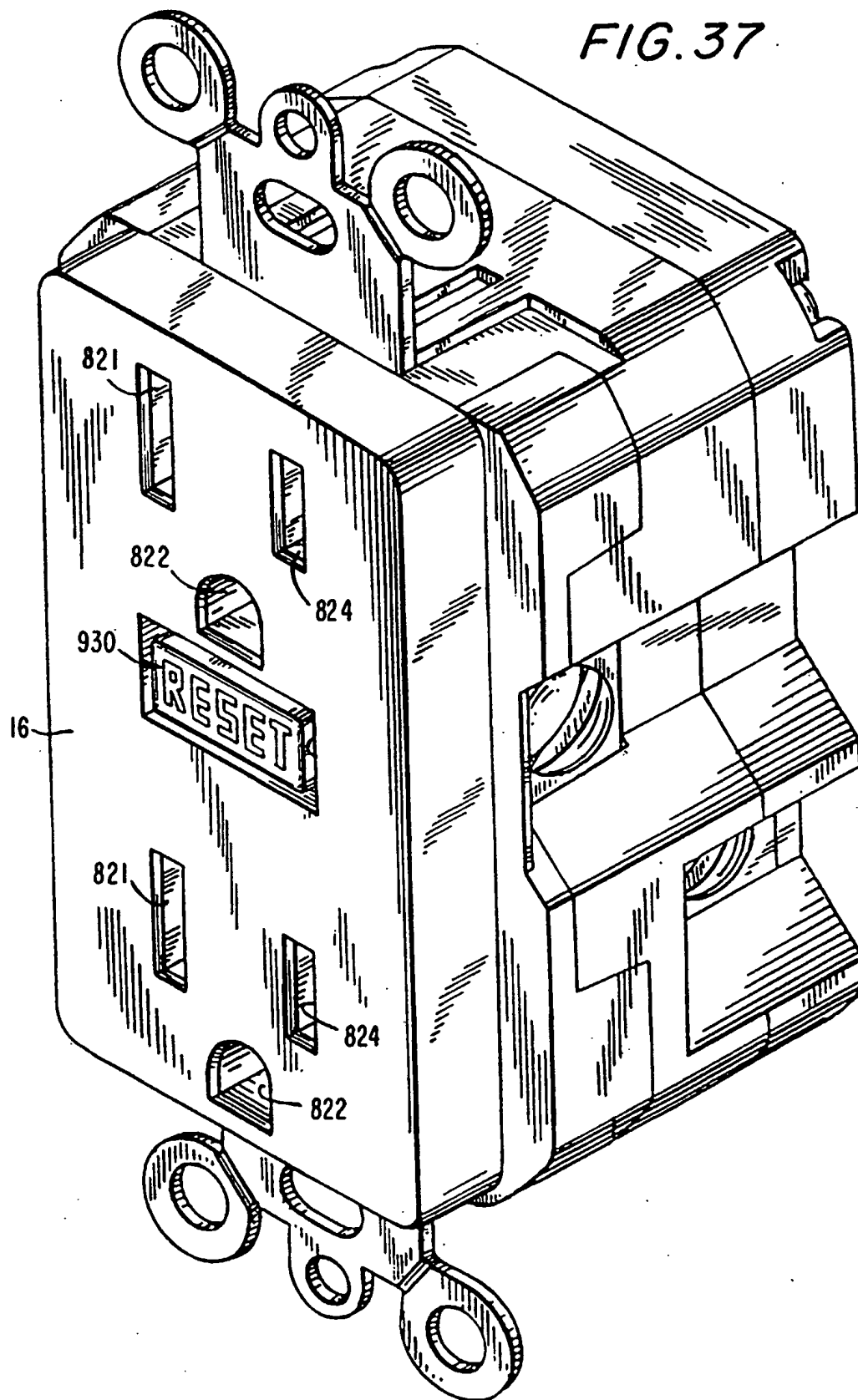


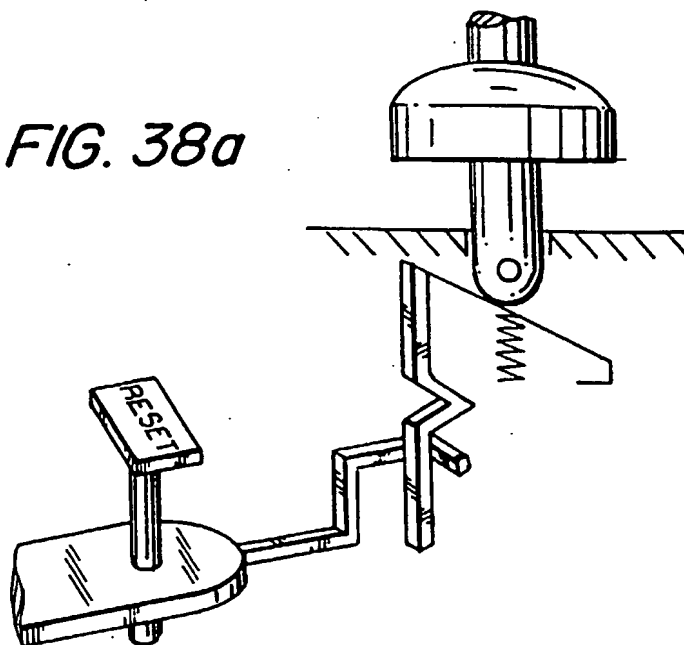
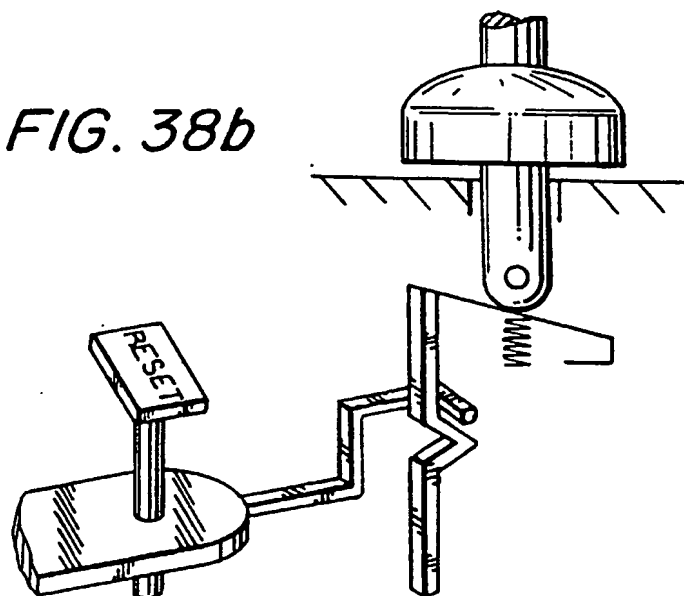
FIG. 38a*FIG. 38b*

FIG. 39

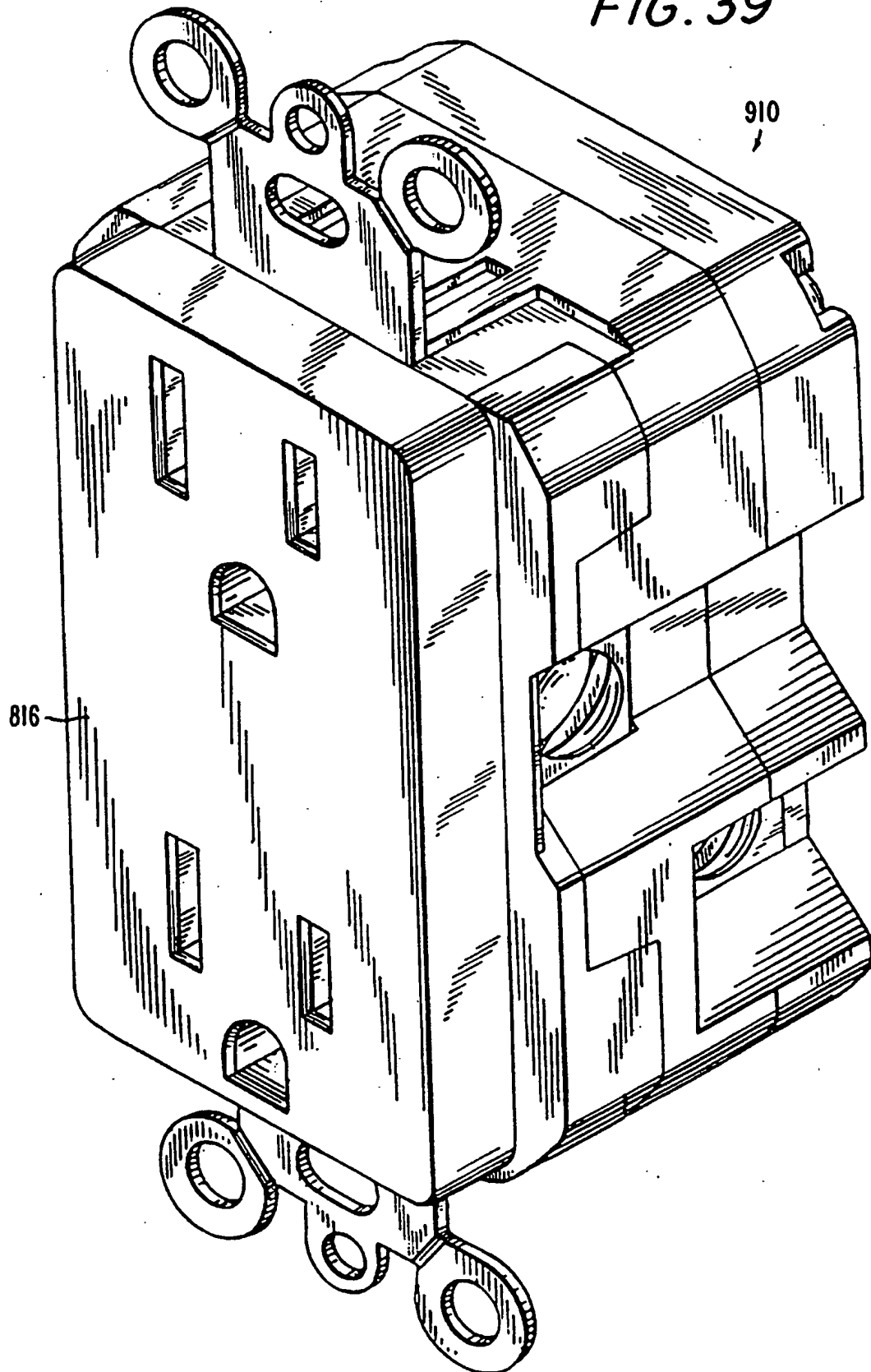


FIG. 40

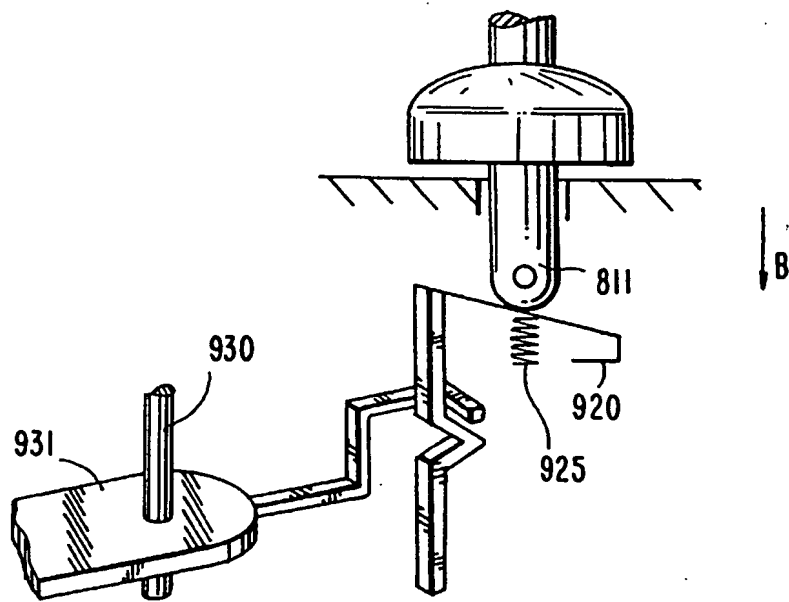
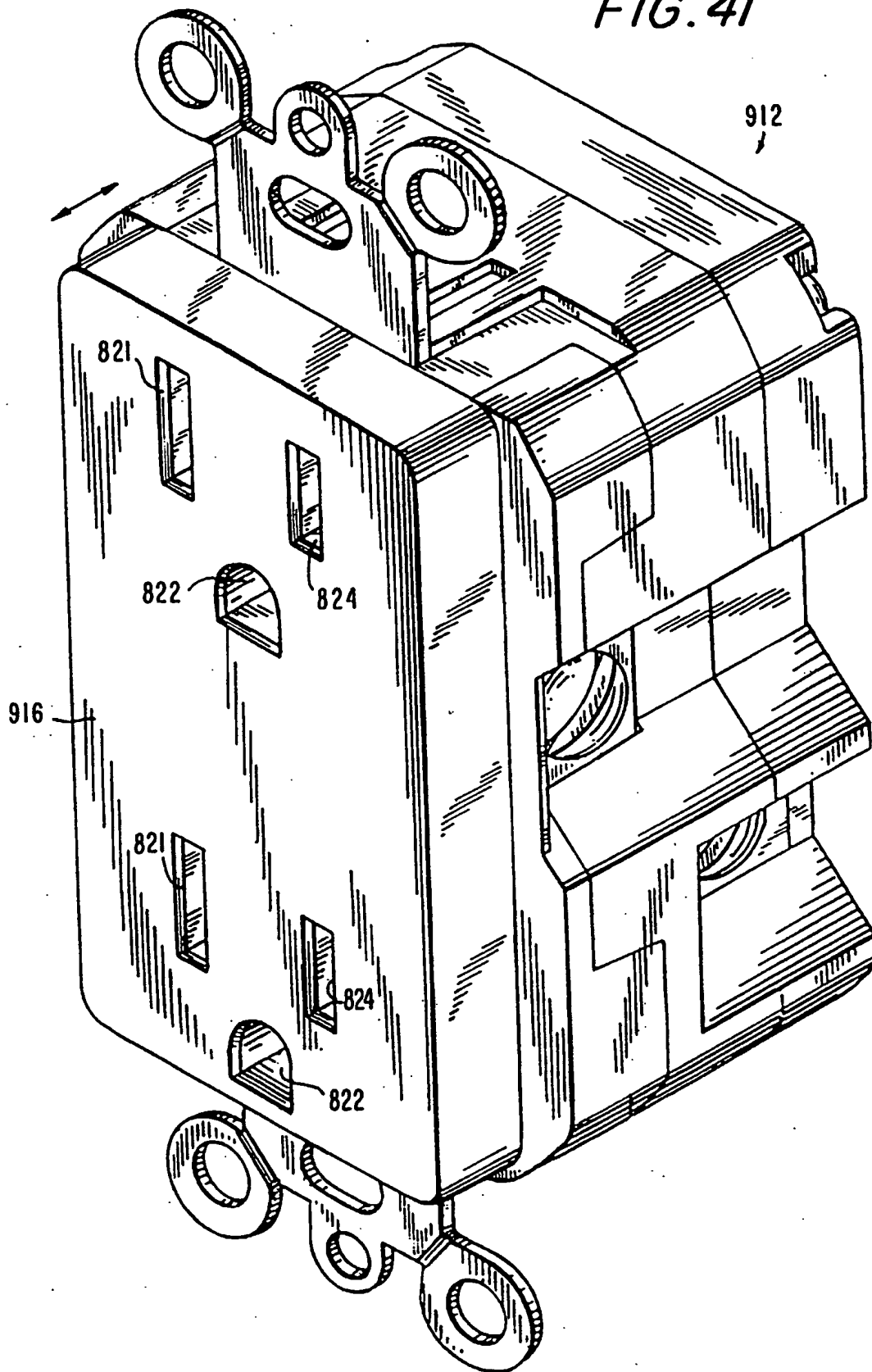


FIG. 41



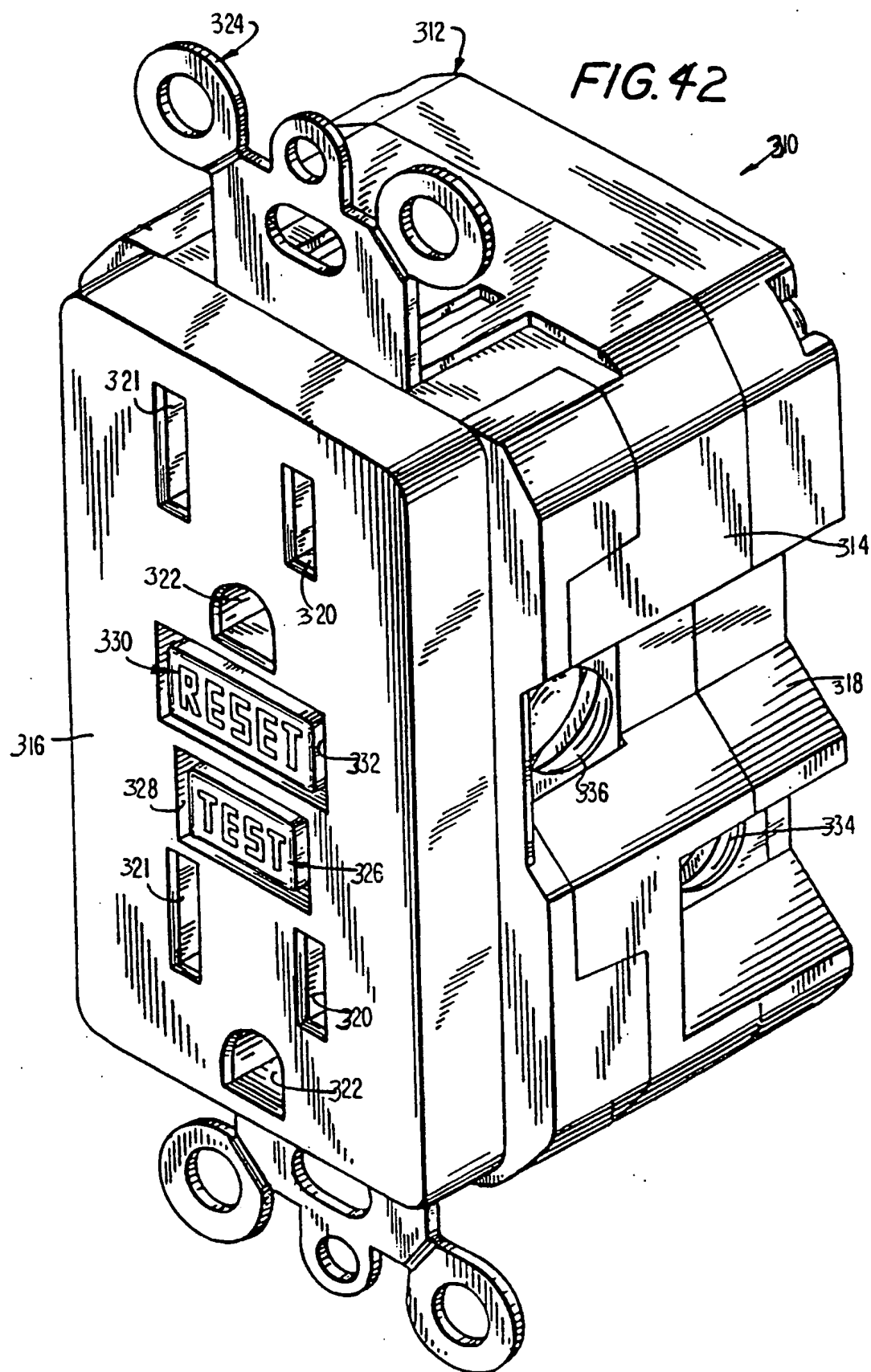
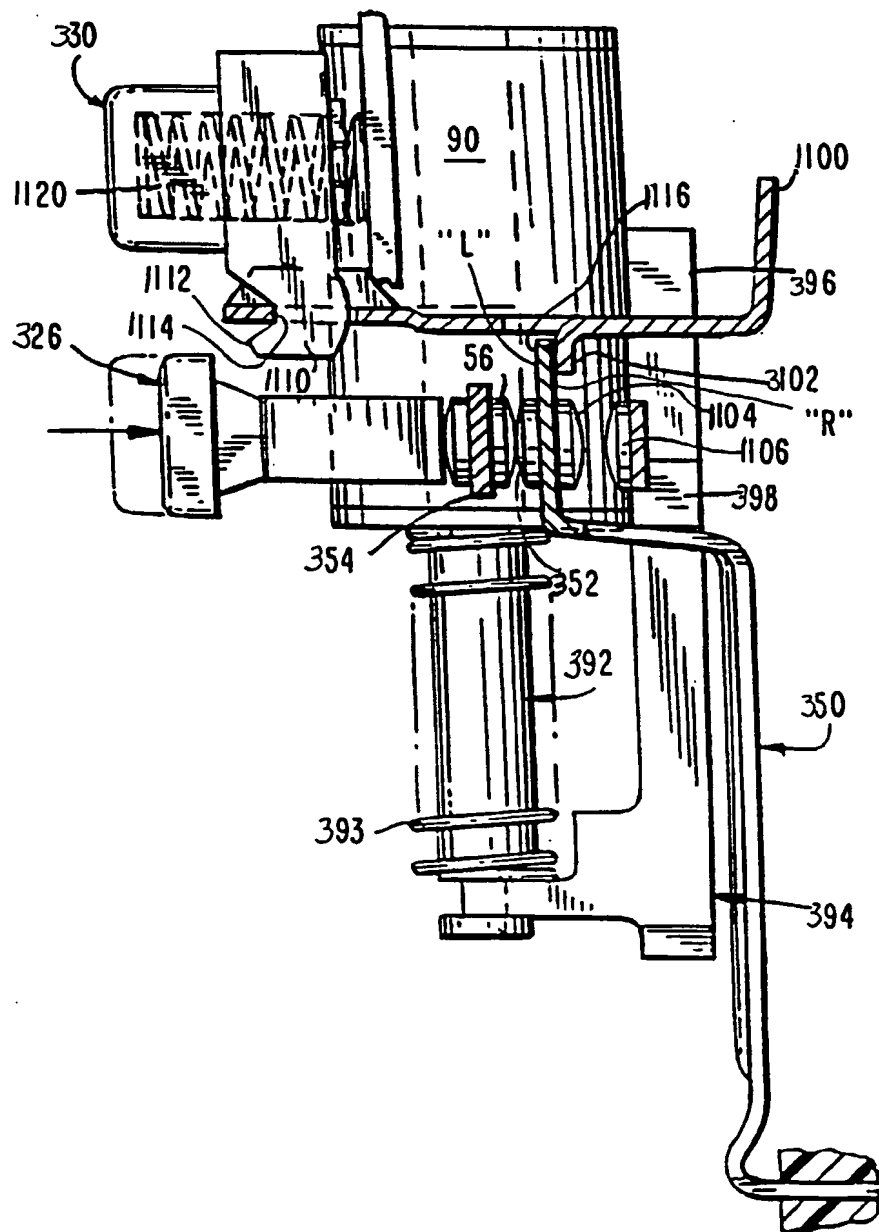


FIG. 43



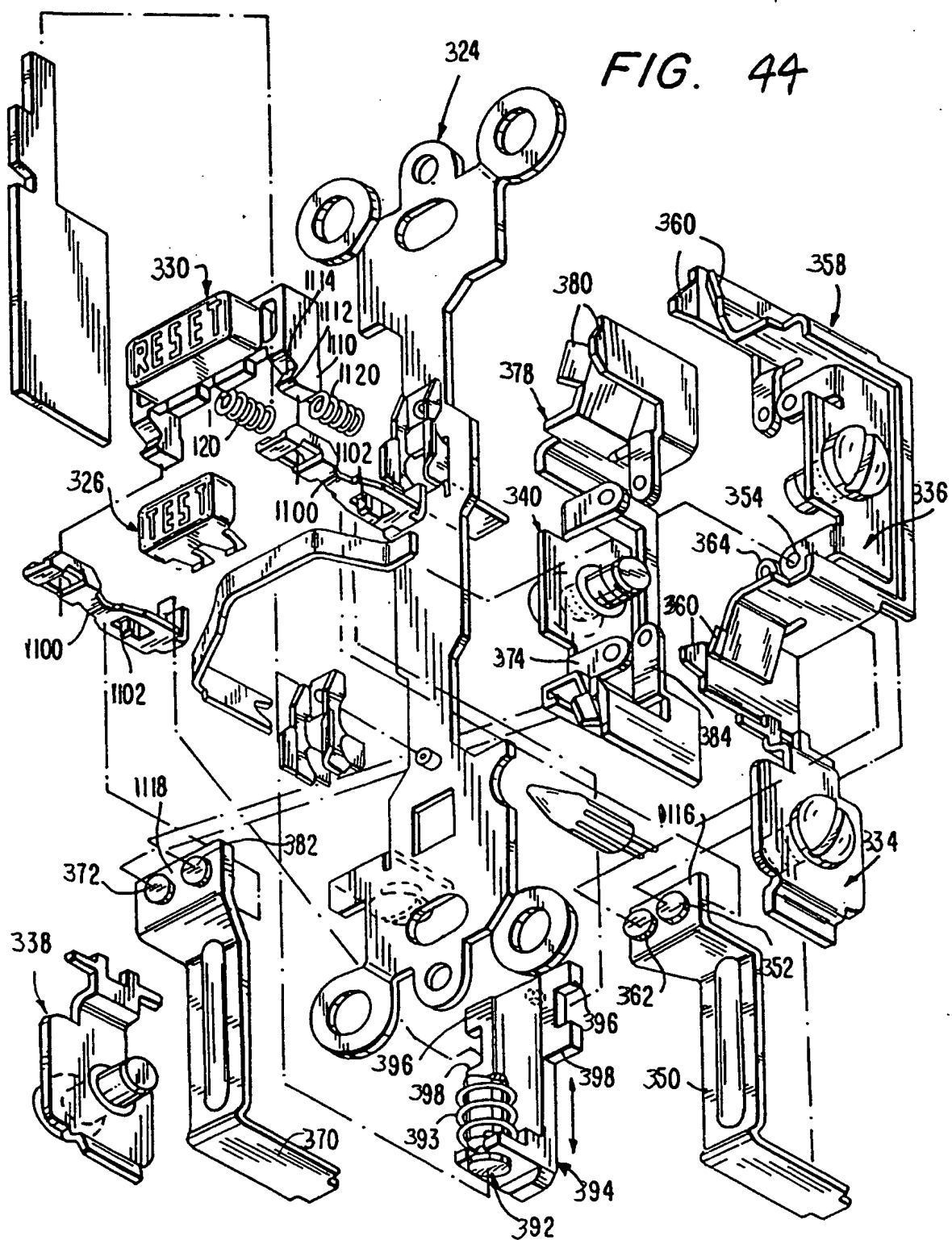


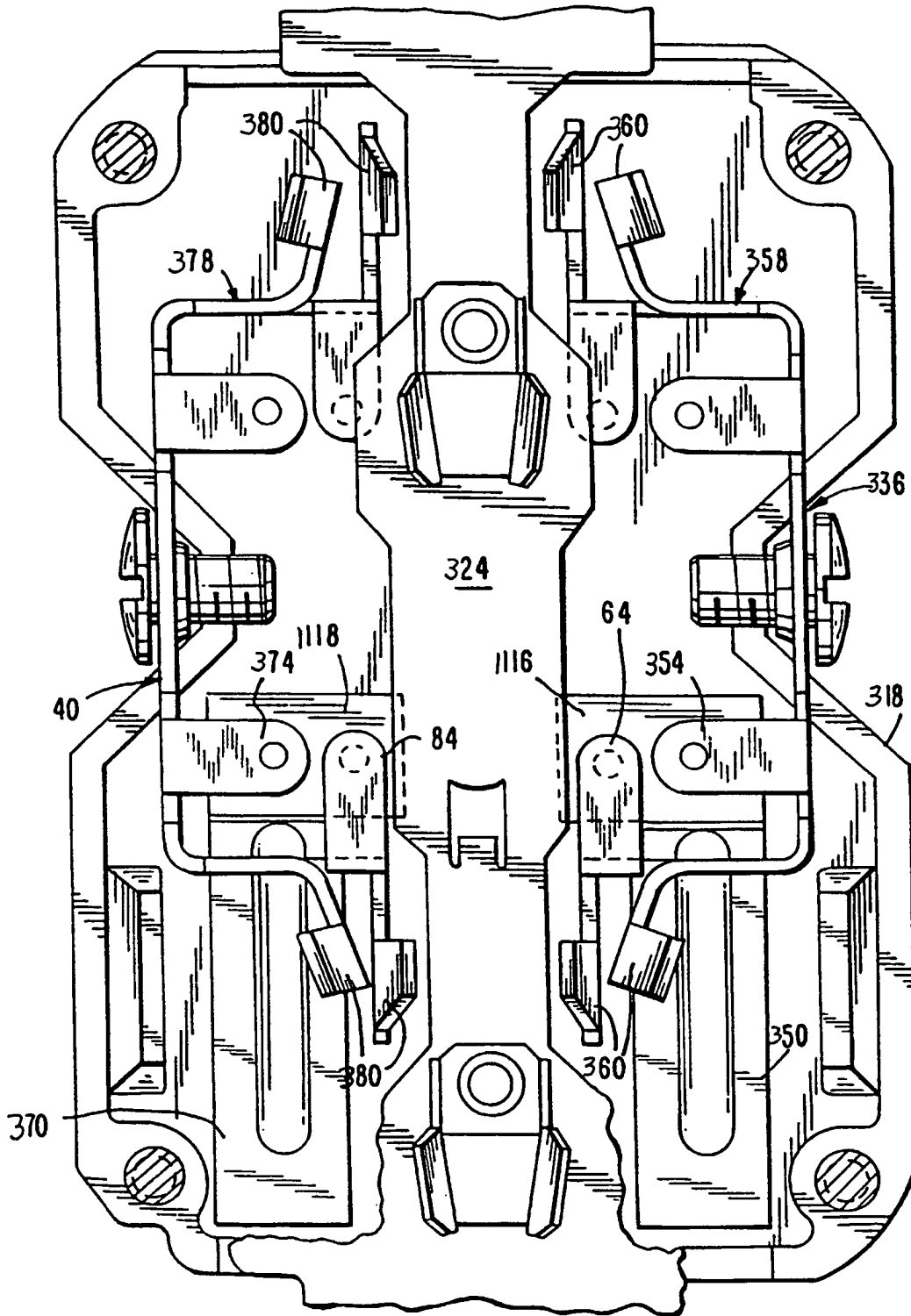
FIG. 45

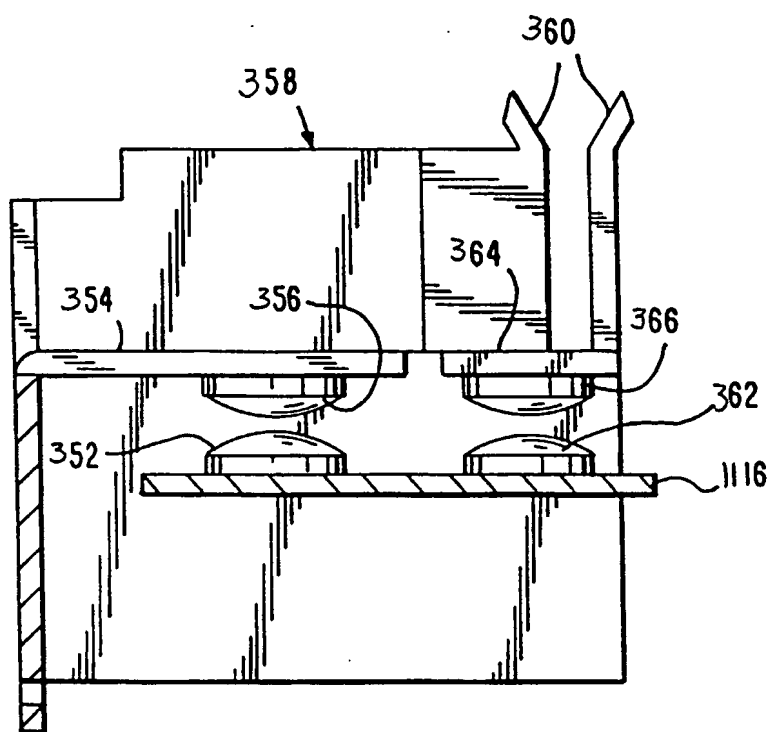
FIG. 46

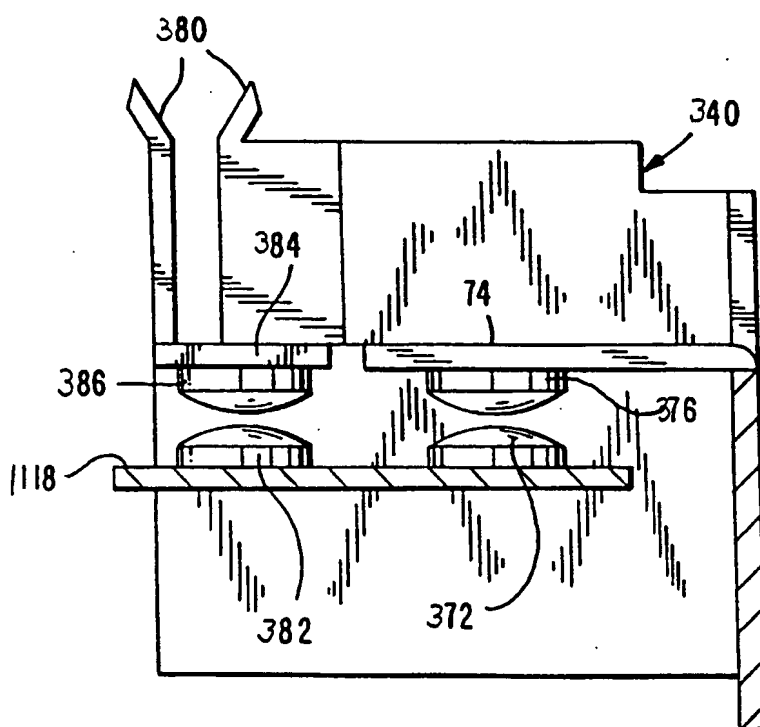
FIG. 47

FIG. 48

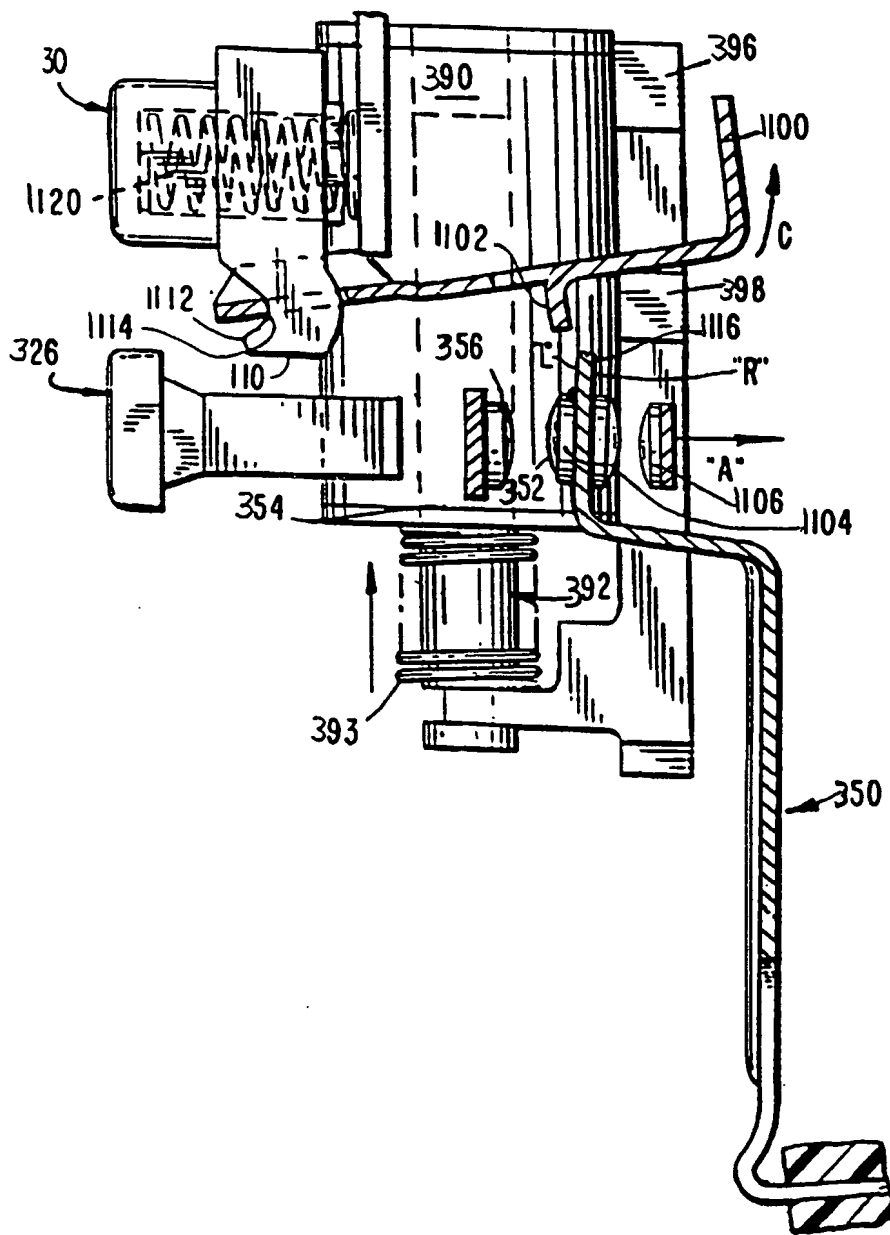


FIG. 49

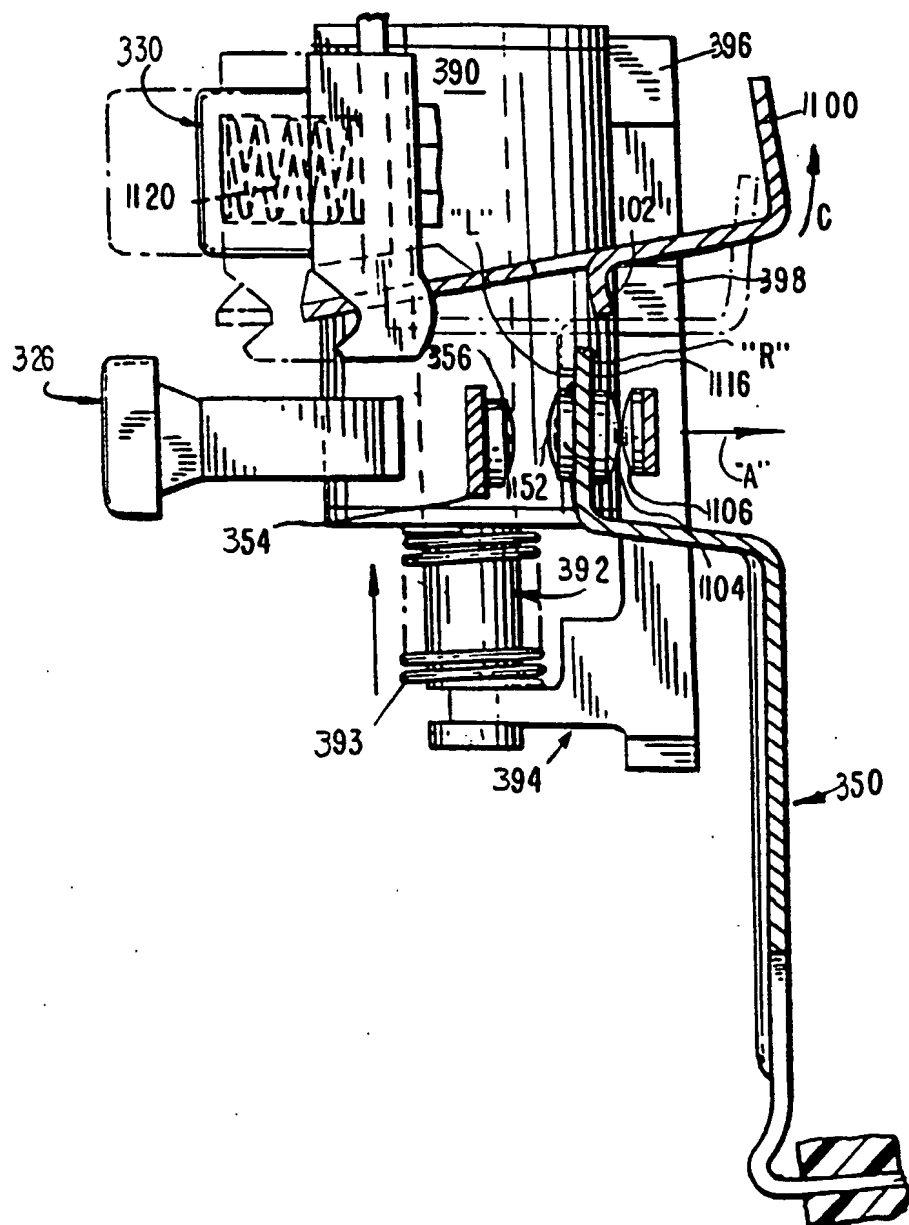


FIG. 50

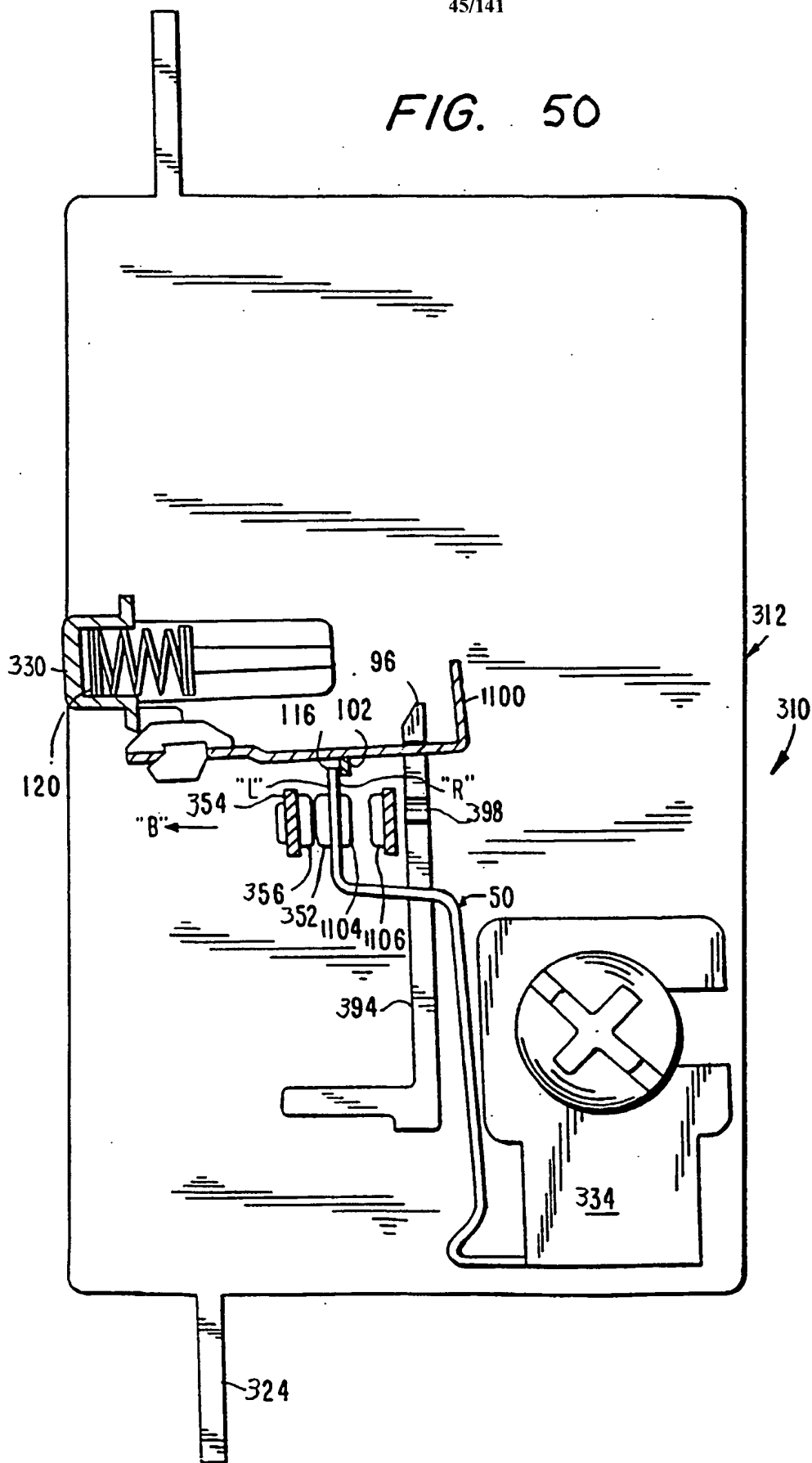


FIG. 51

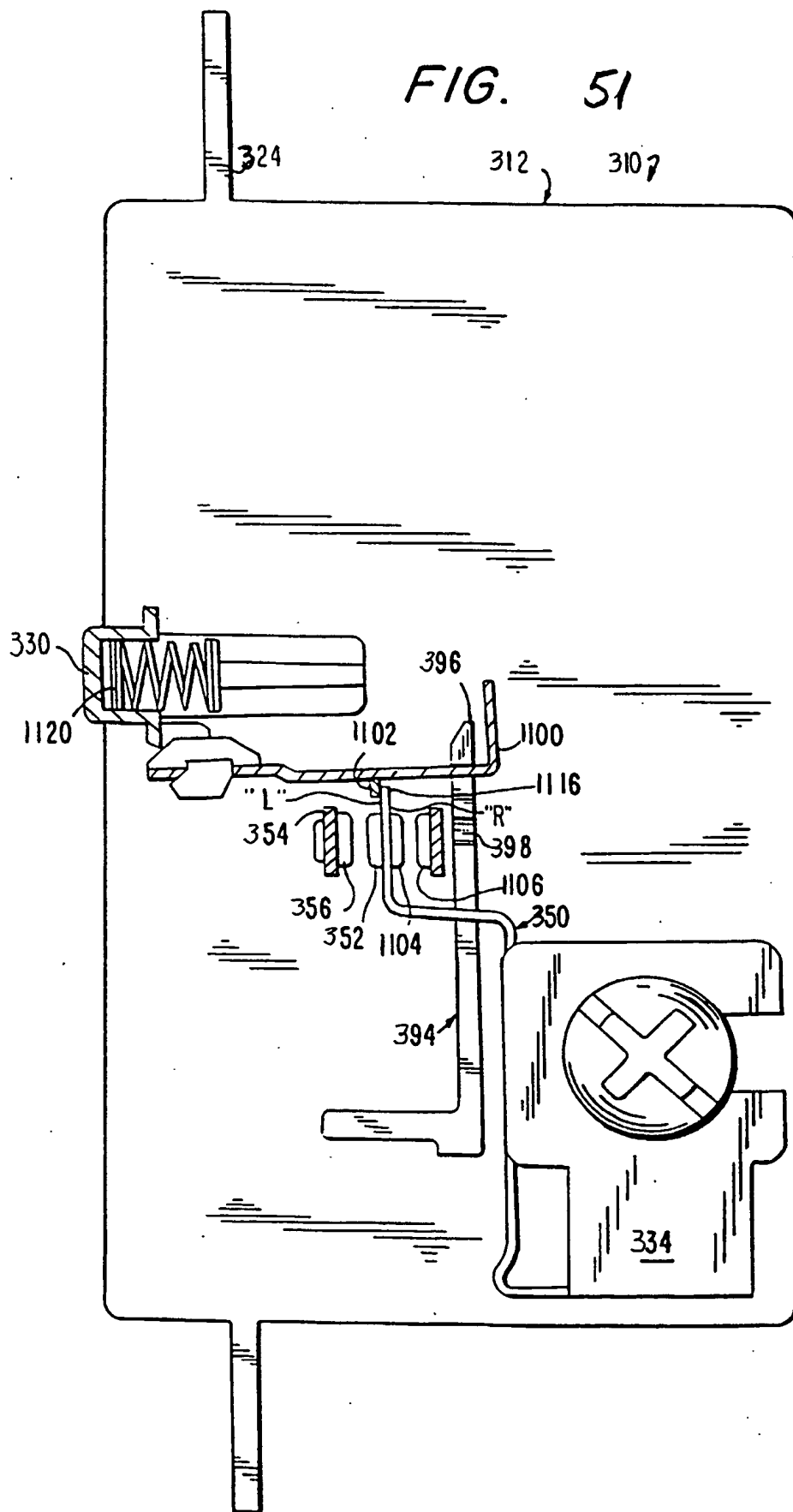


FIG. 52

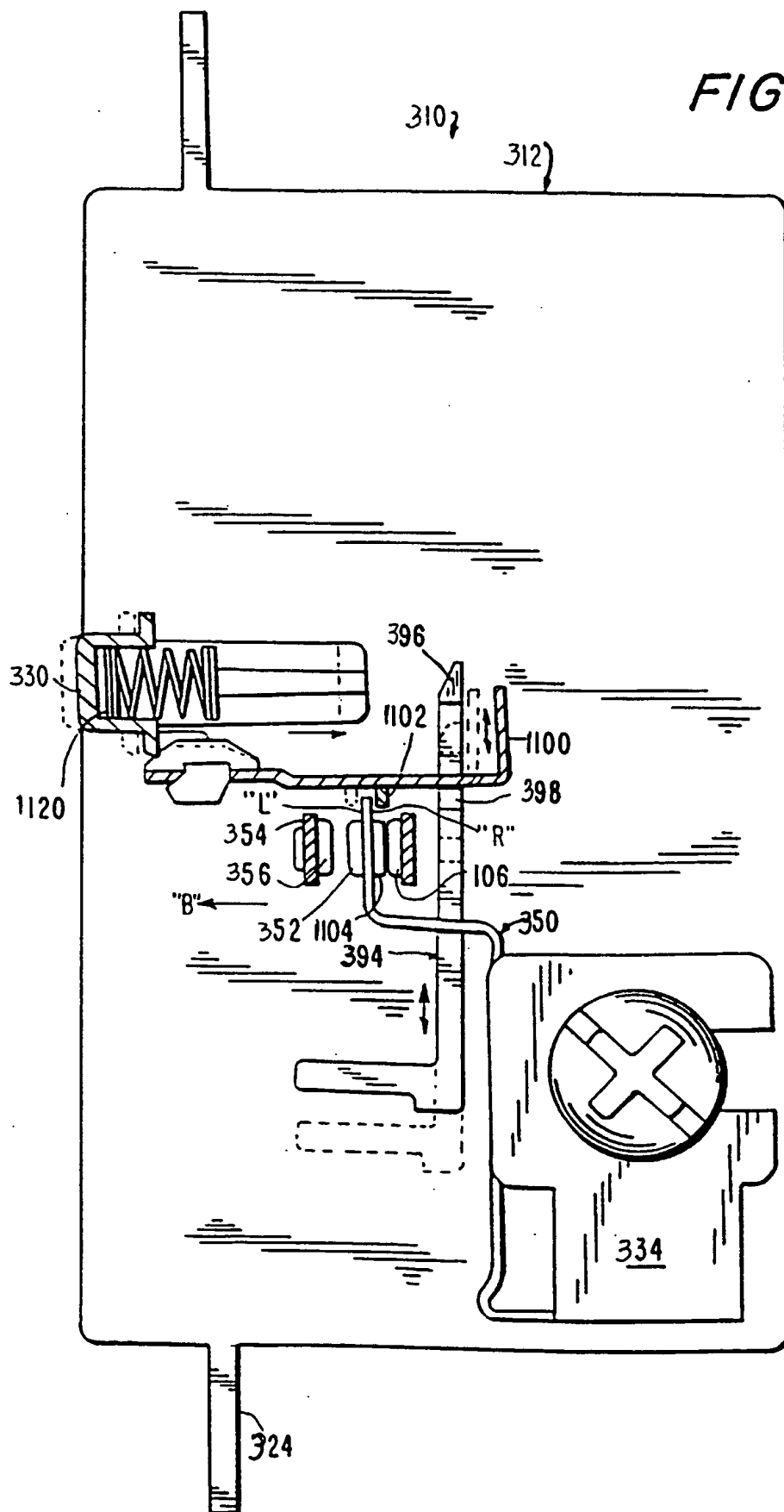


FIG. 53

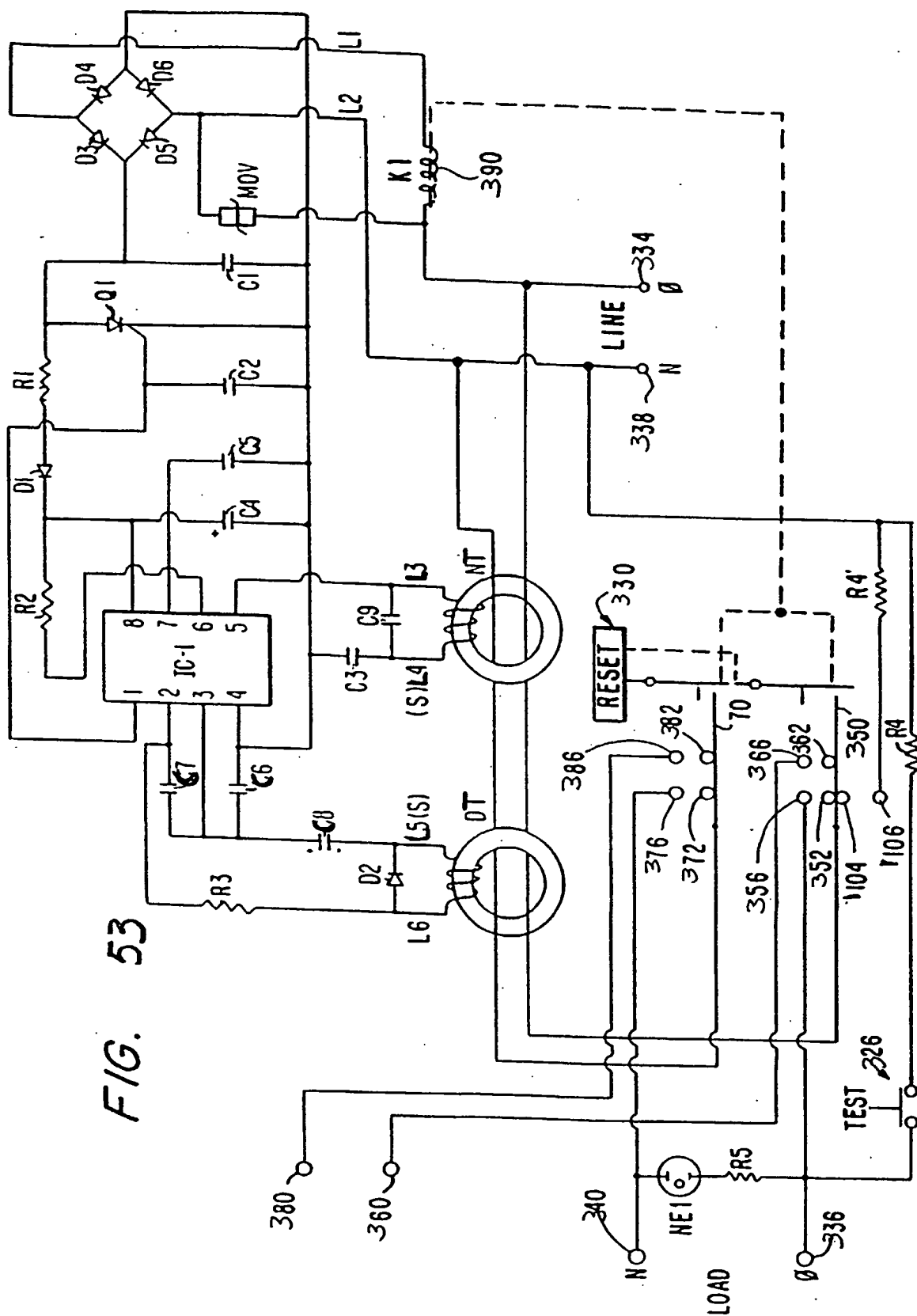


FIG. 54

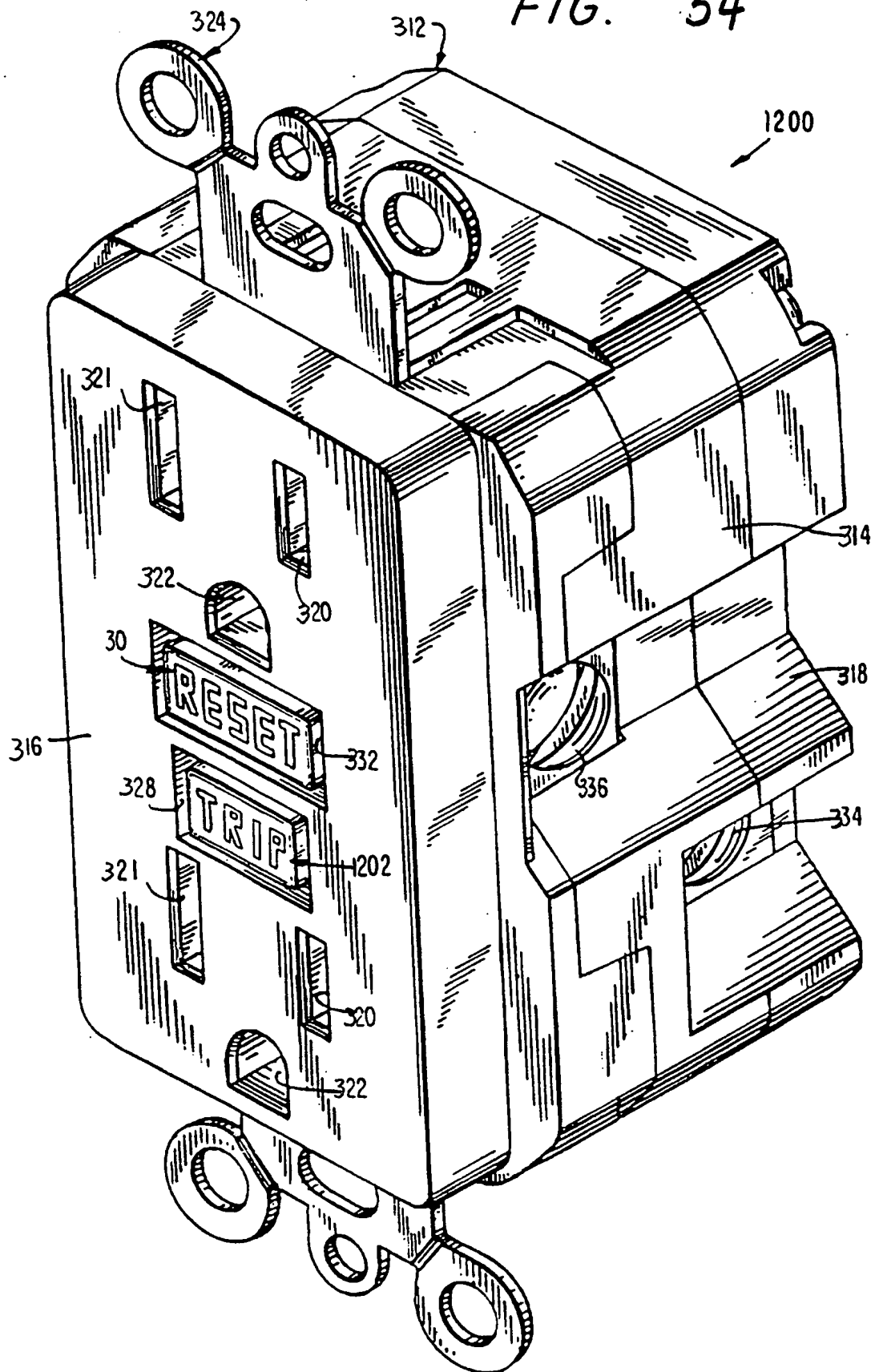


FIG. 55

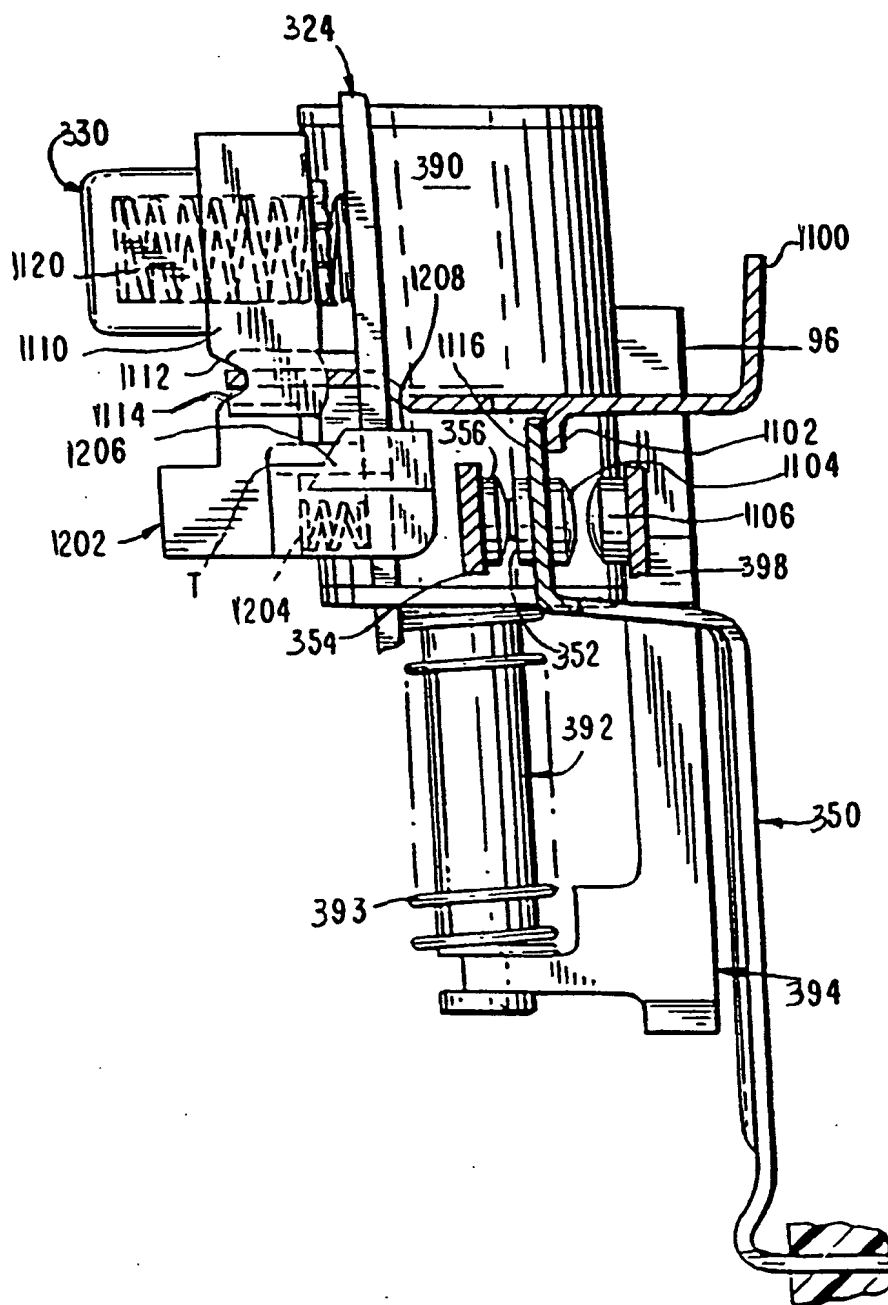


FIG. 56

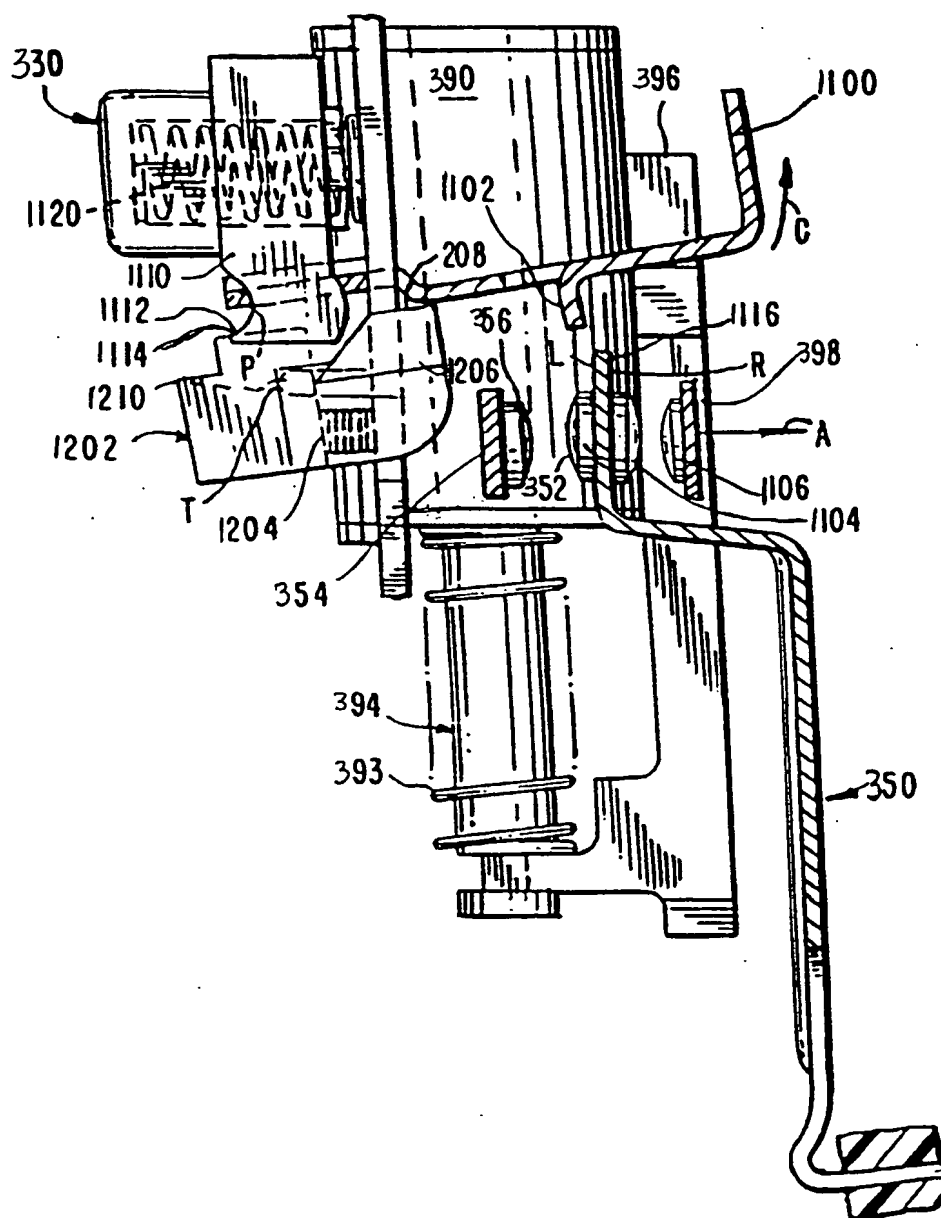


FIG. 57

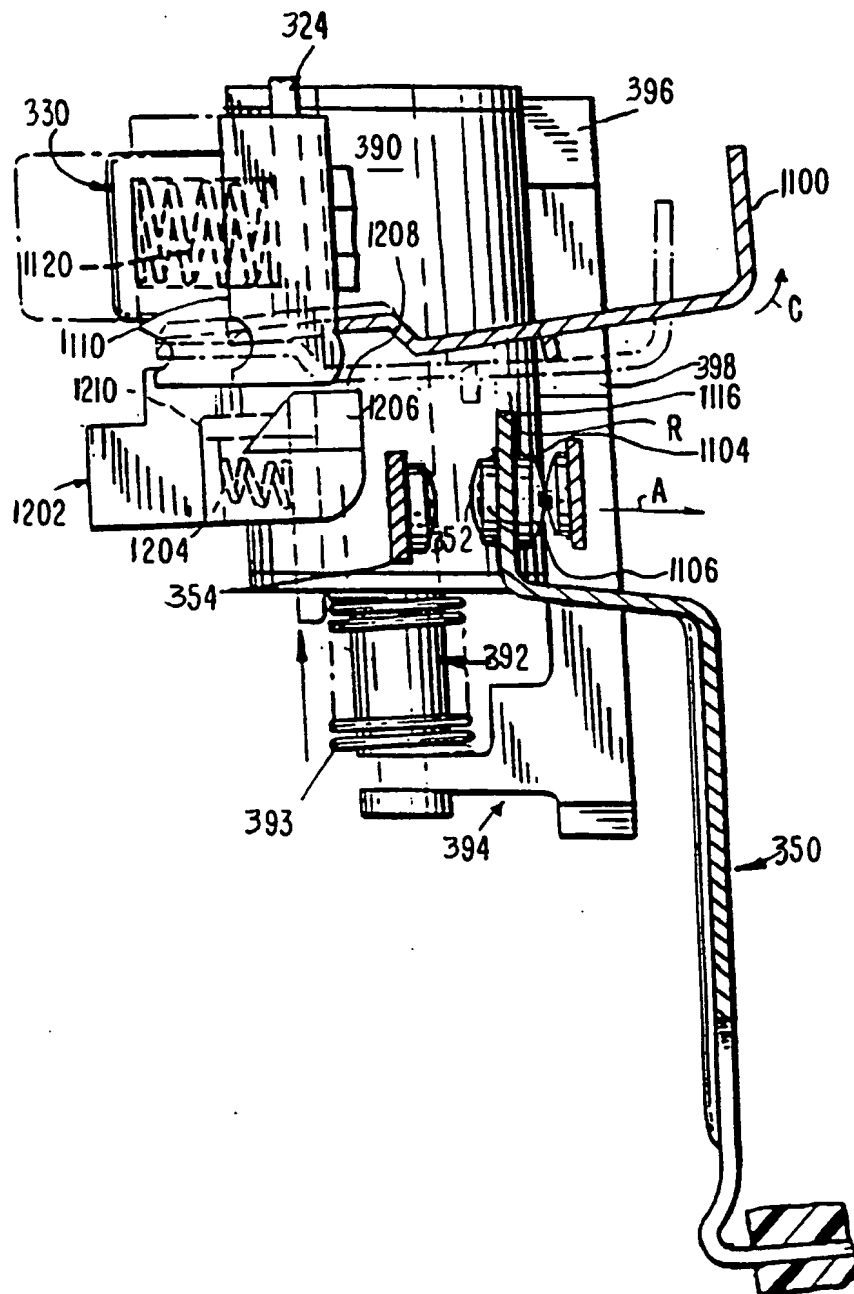


FIG. 58

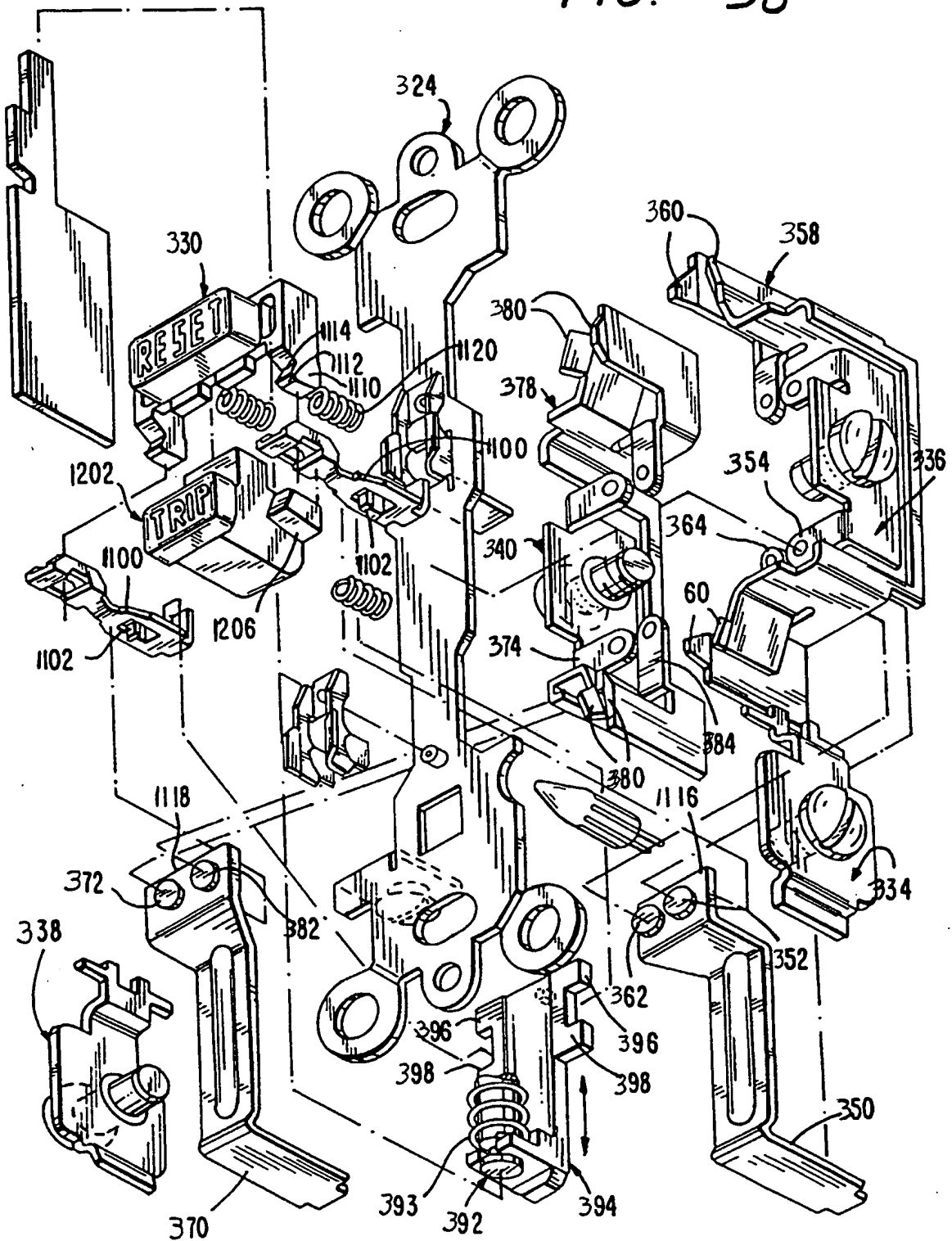


FIG. 59

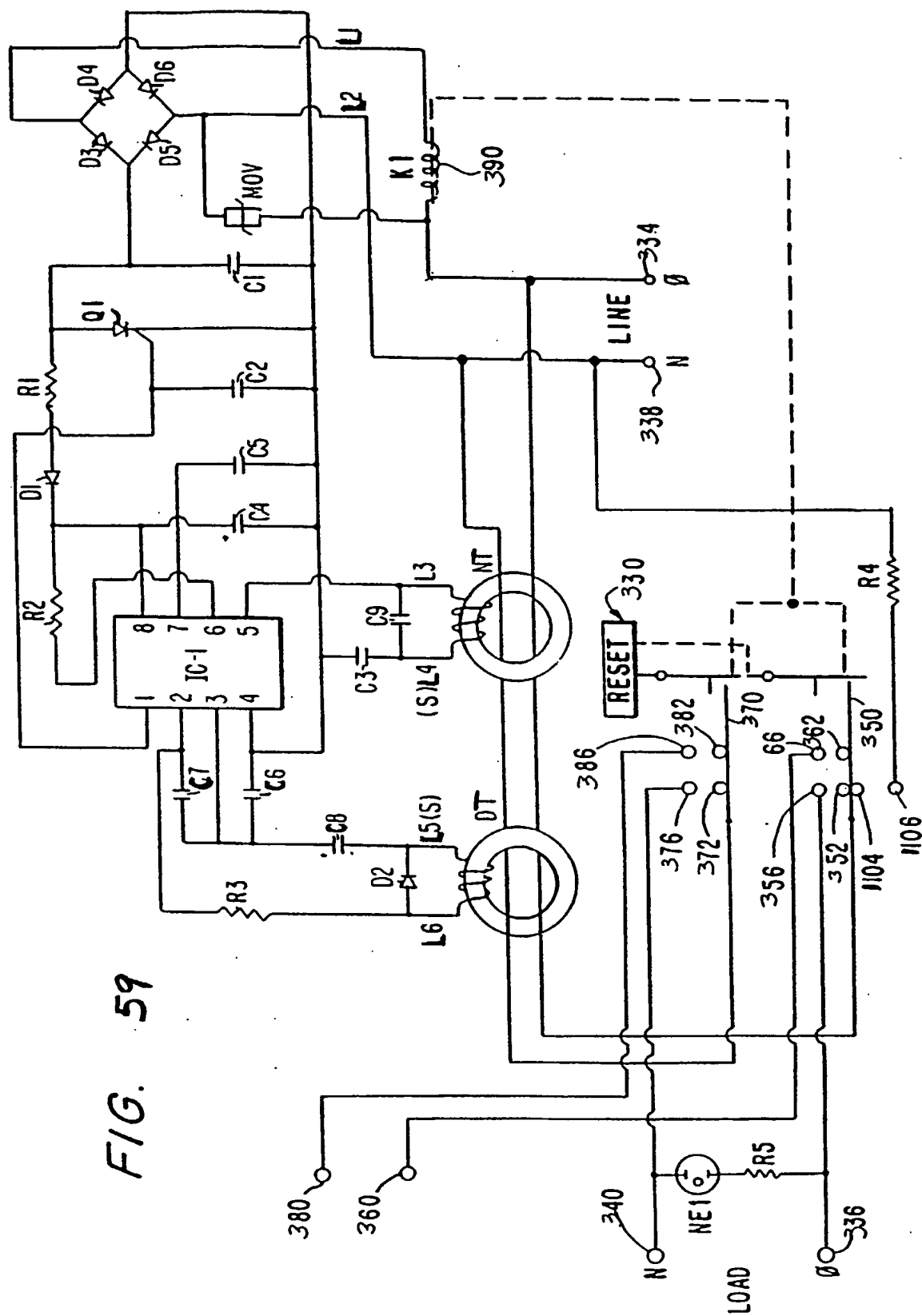
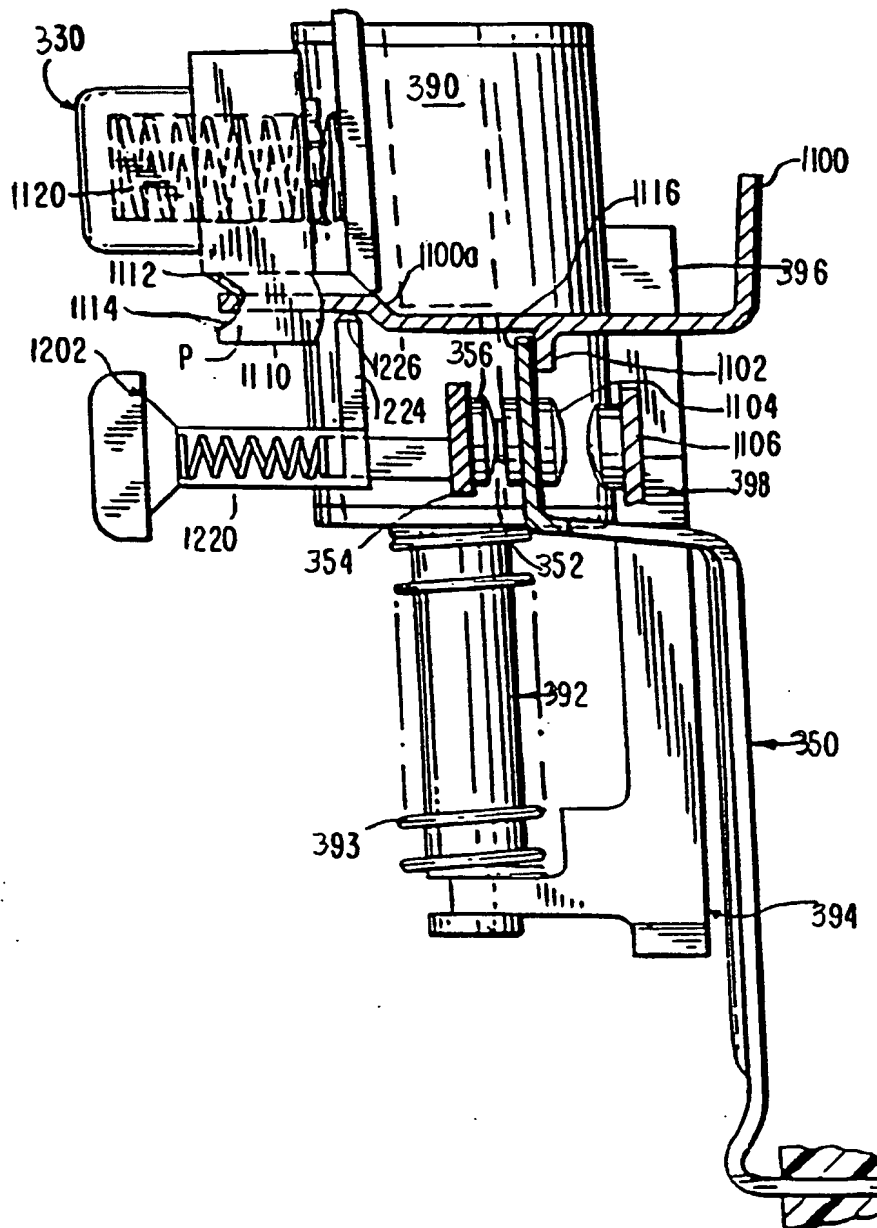


FIG. 60



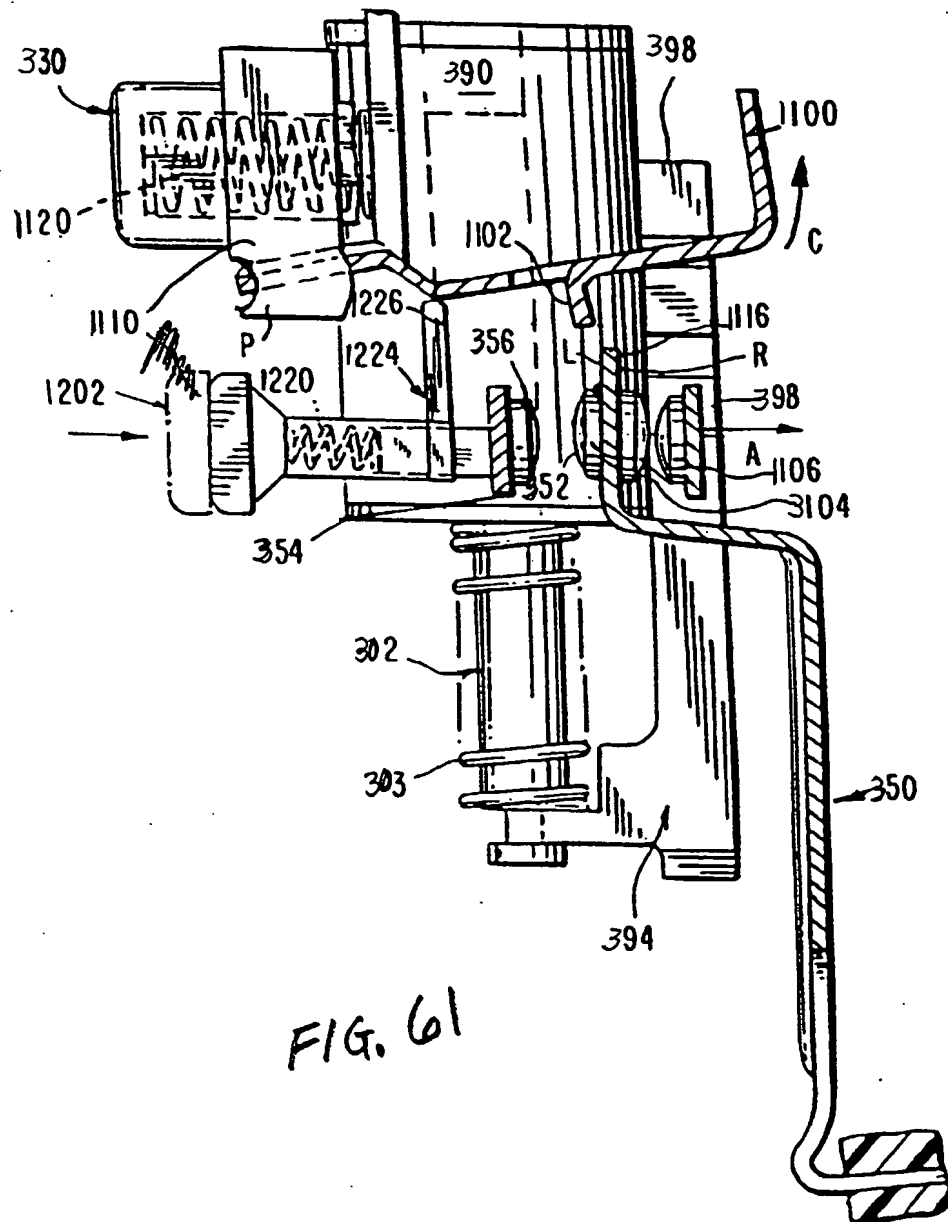


FIG. 62

1240

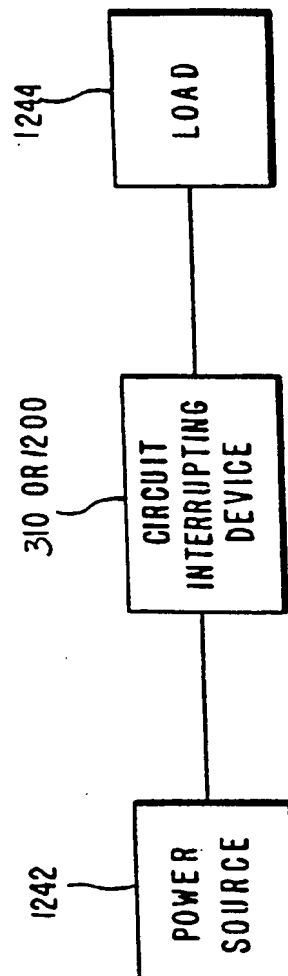


FIG. 63a

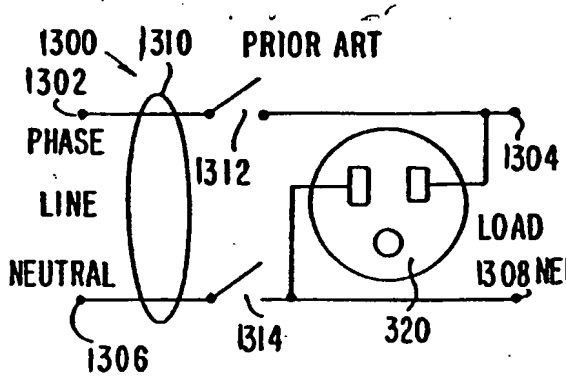


FIG. 63b

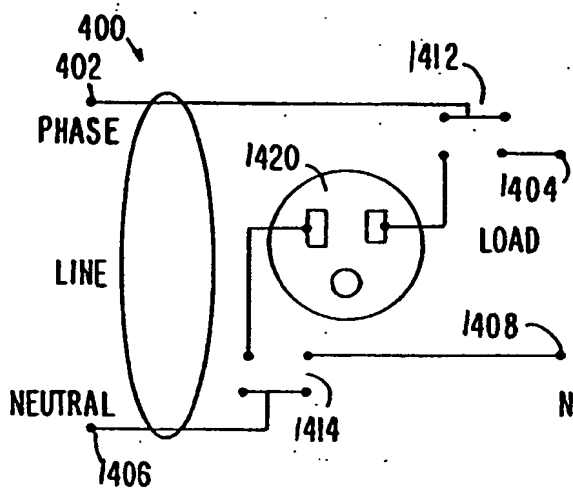
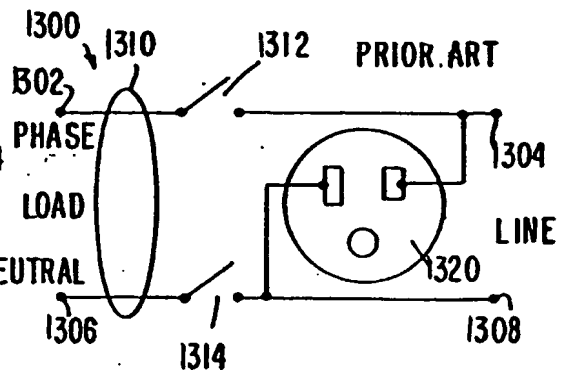


FIG. 64a

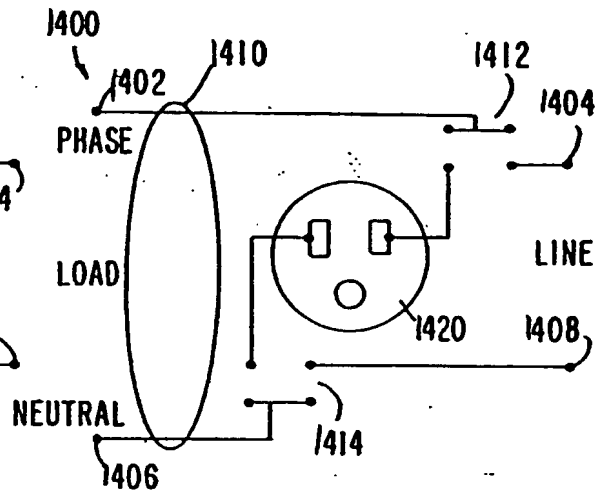


FIG. 64b

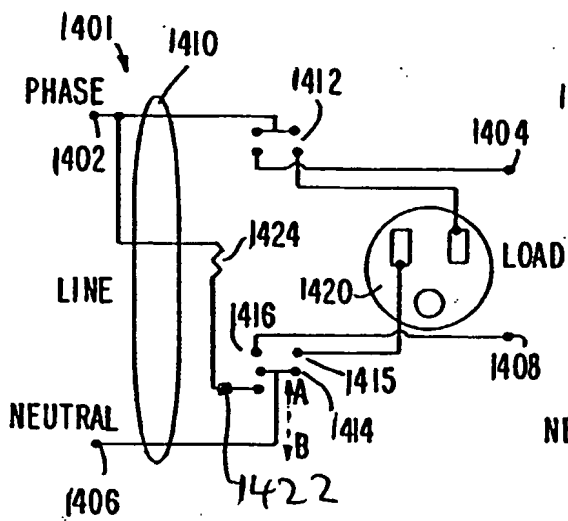


FIG. 65a

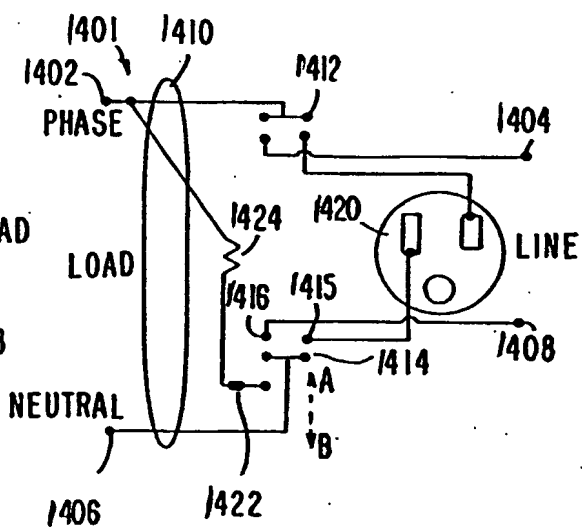


FIG. 65b

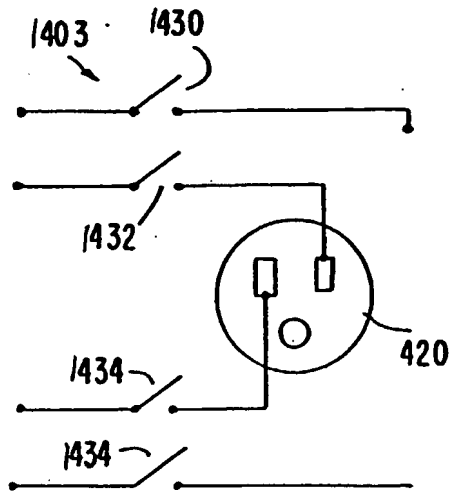


FIG. 66a

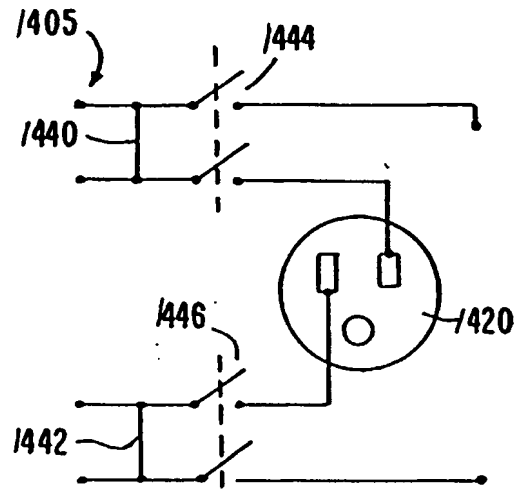


FIG. 66b

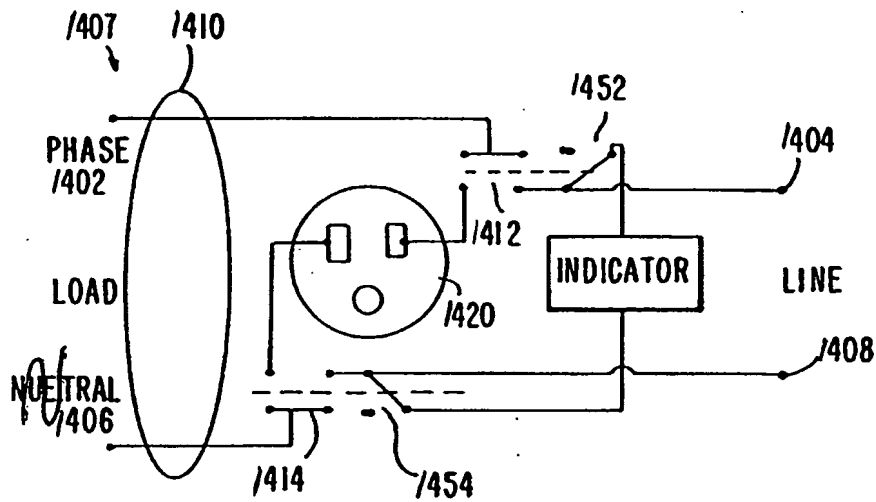


FIG. 67

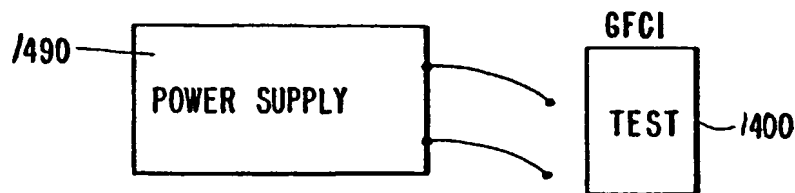


FIG. 68

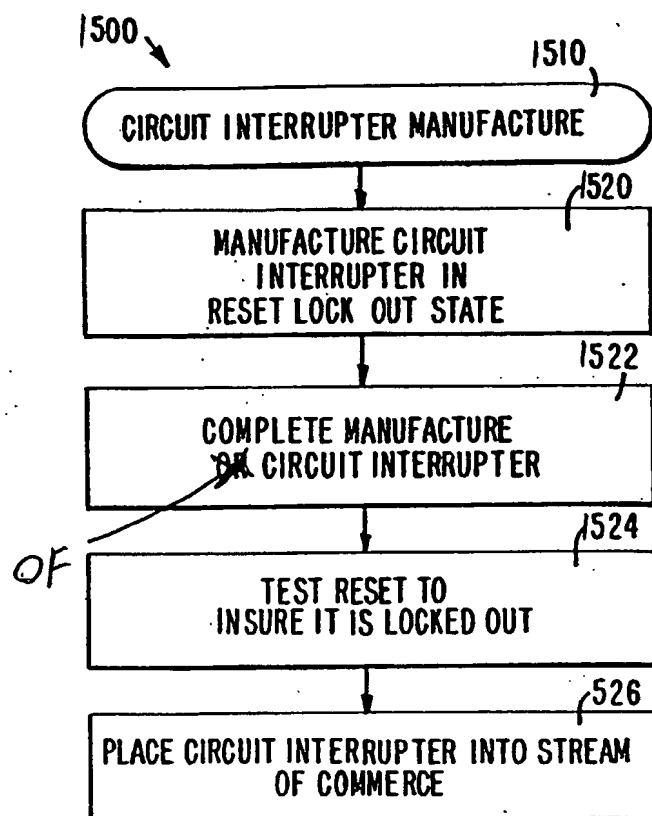


FIG. 69a

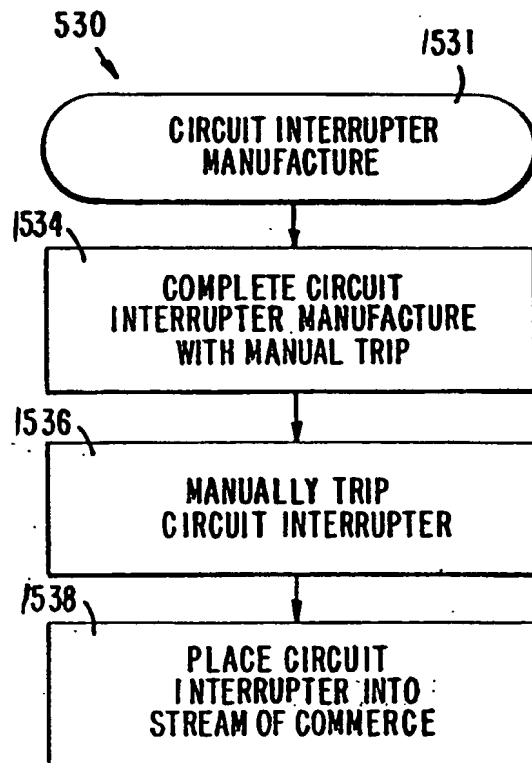


FIG. 69b

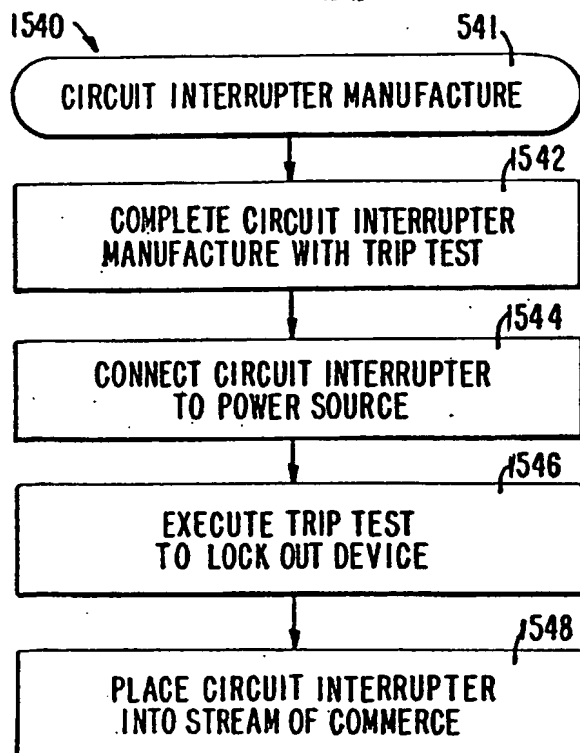


FIG. 69c

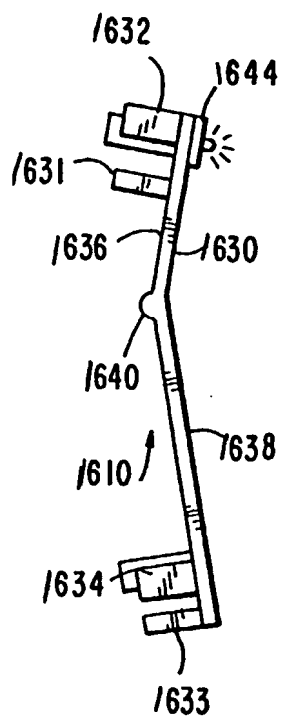


FIG. 70

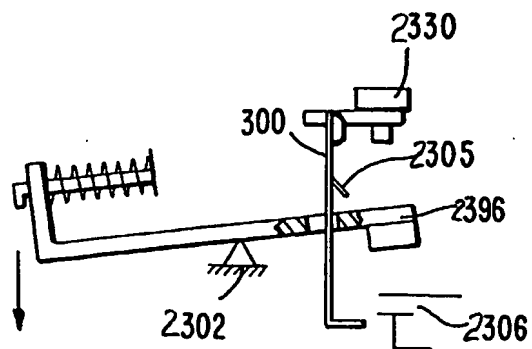
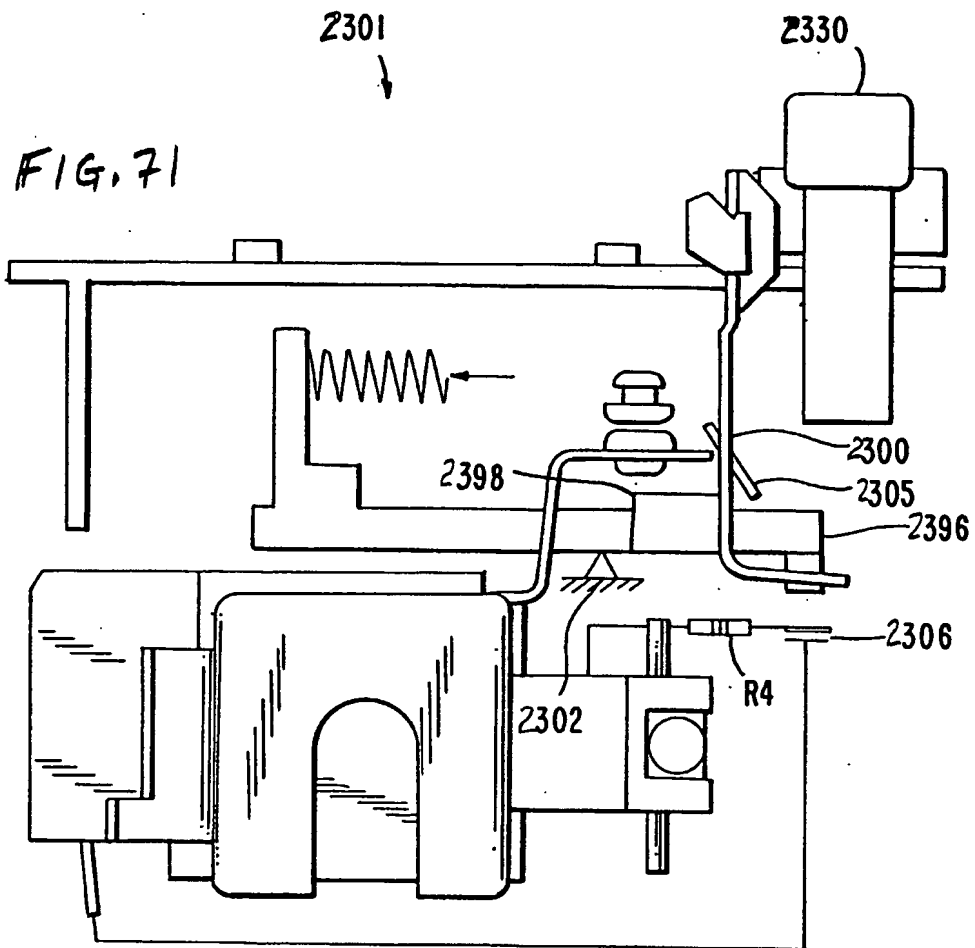


FIG. 72a

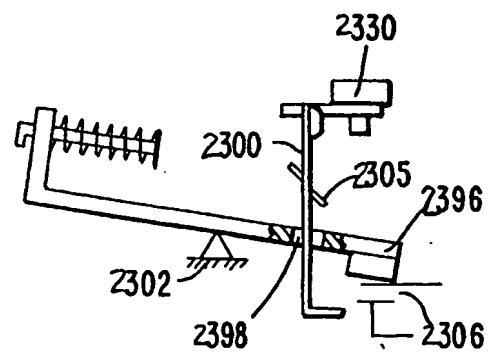


FIG. 72b

FIG. 74a

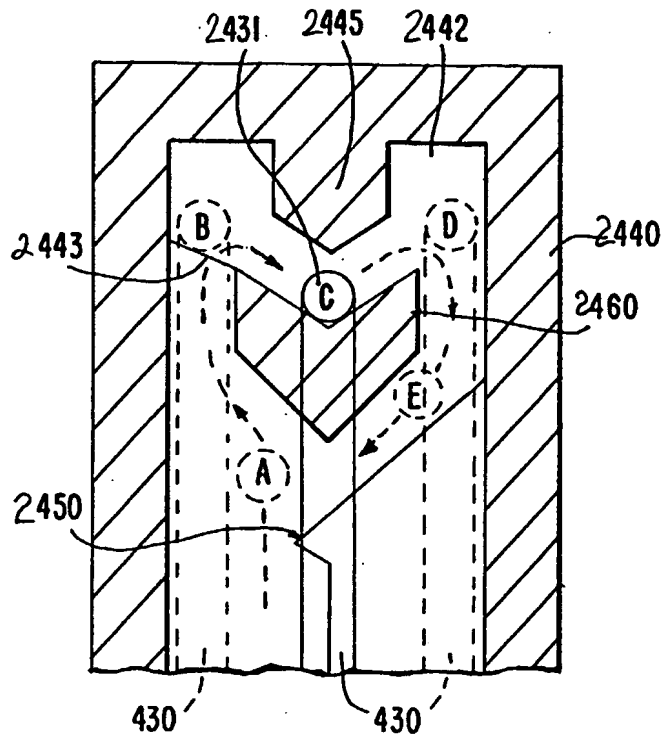
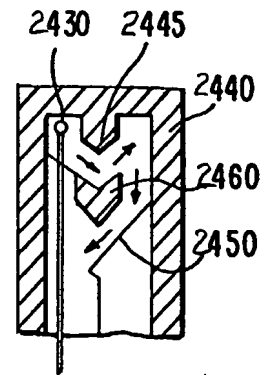


FIG. 74b



2096

FIG. 75a

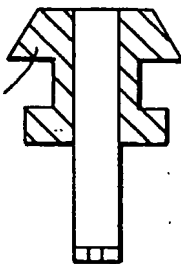


FIG. 75b

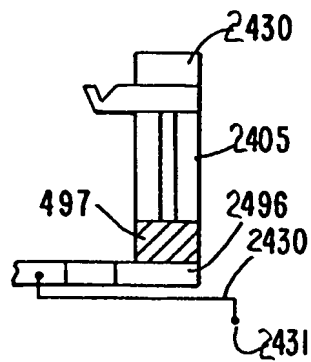
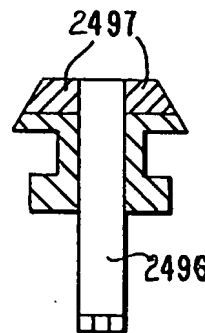


FIG. 76a

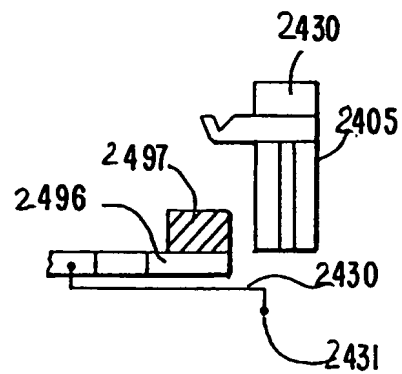
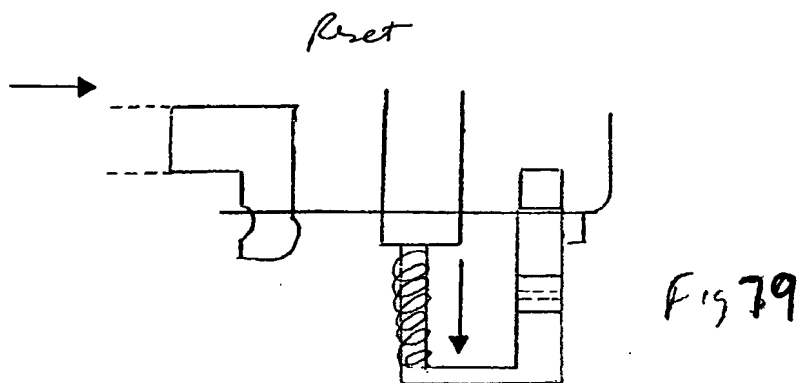
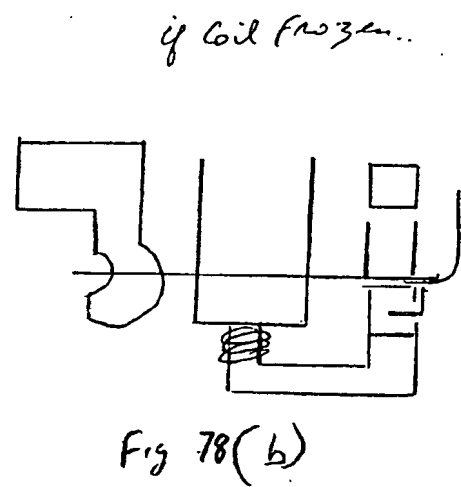
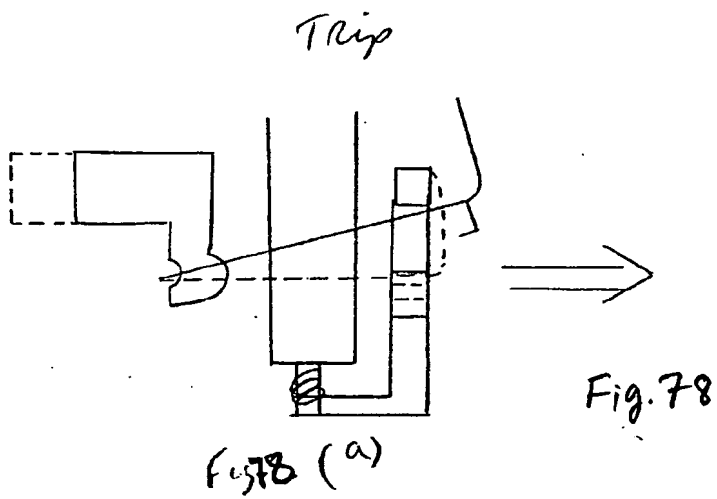
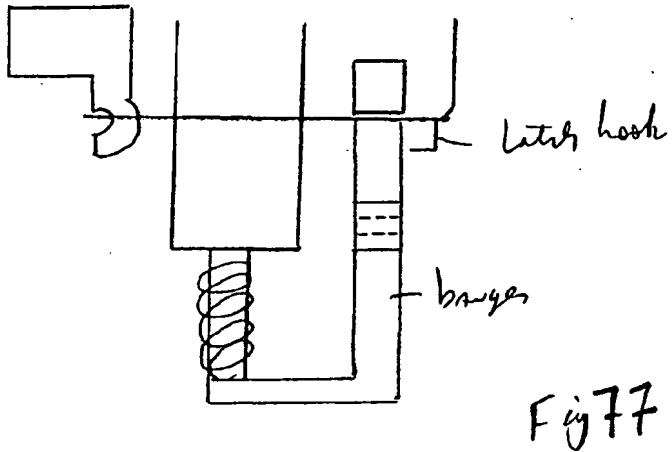


FIG. 76b



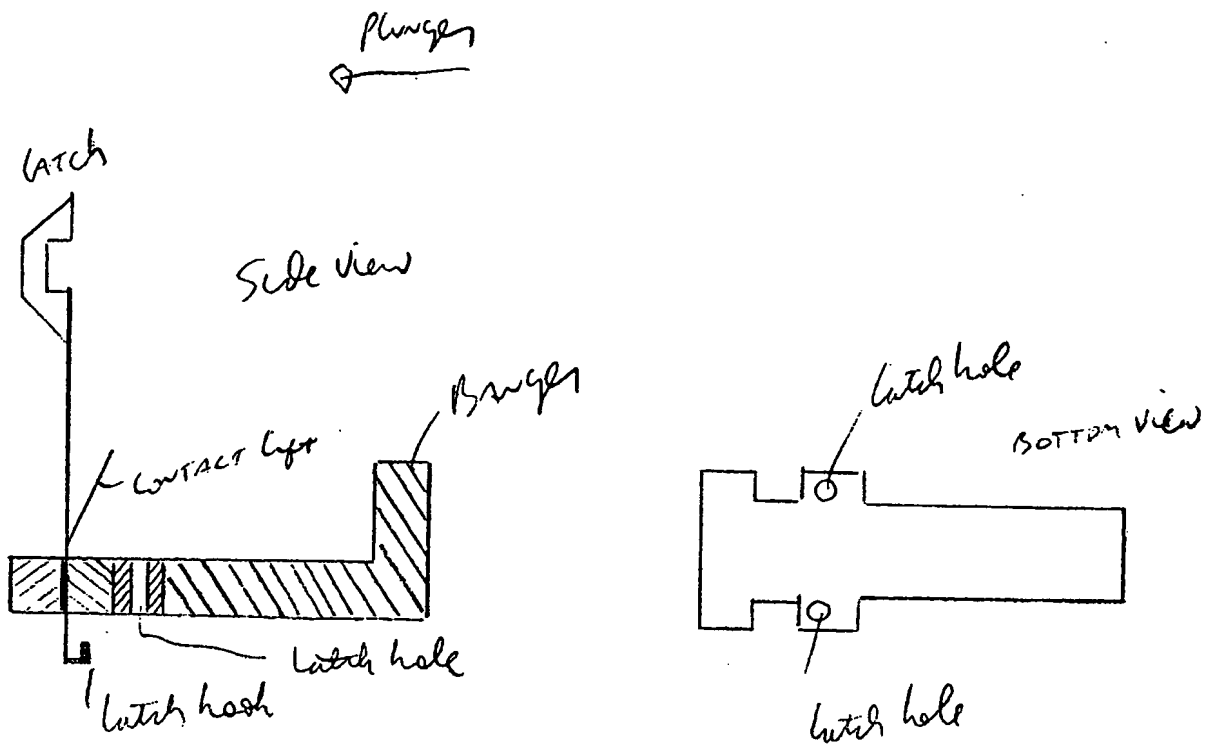


Fig 80

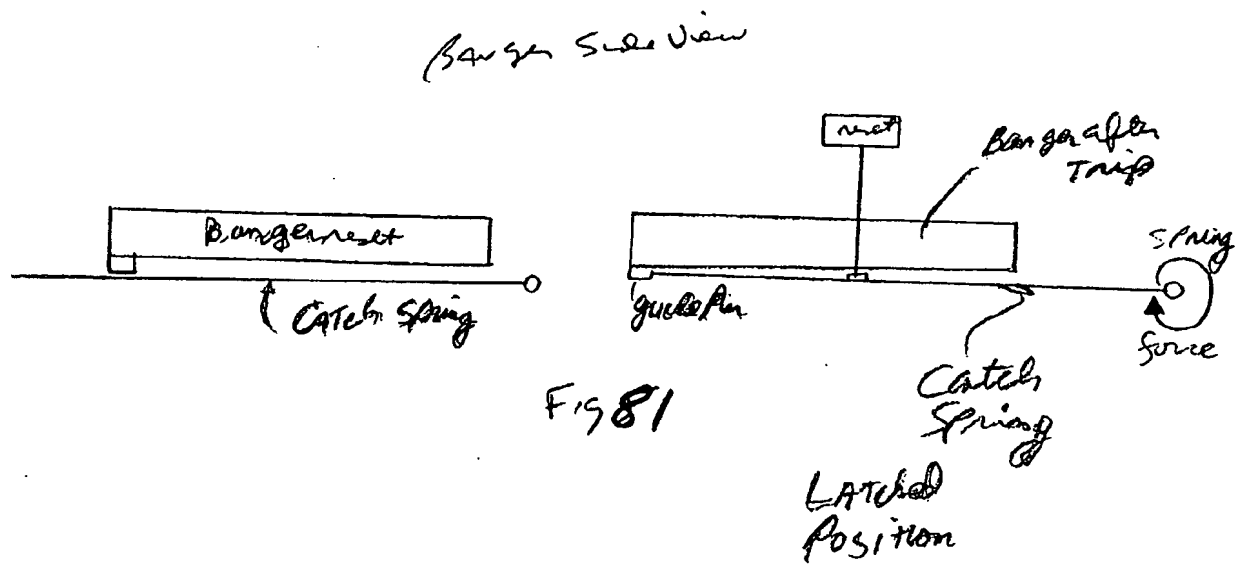
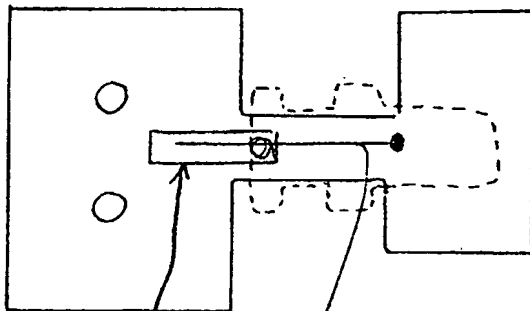


Fig. 82a

Bottom View Reset

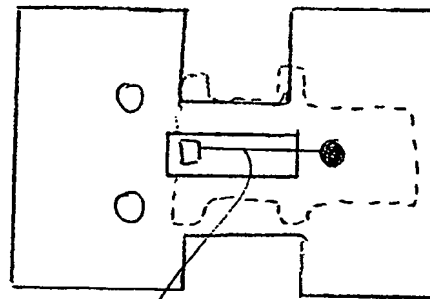


Bridge
guide
pin
slot

Spring force
toward
Bridge

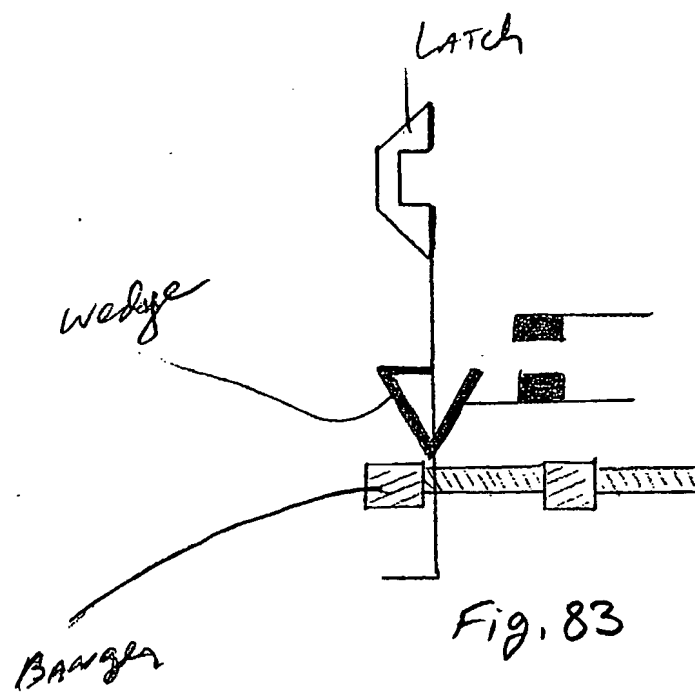
Fig. 82b

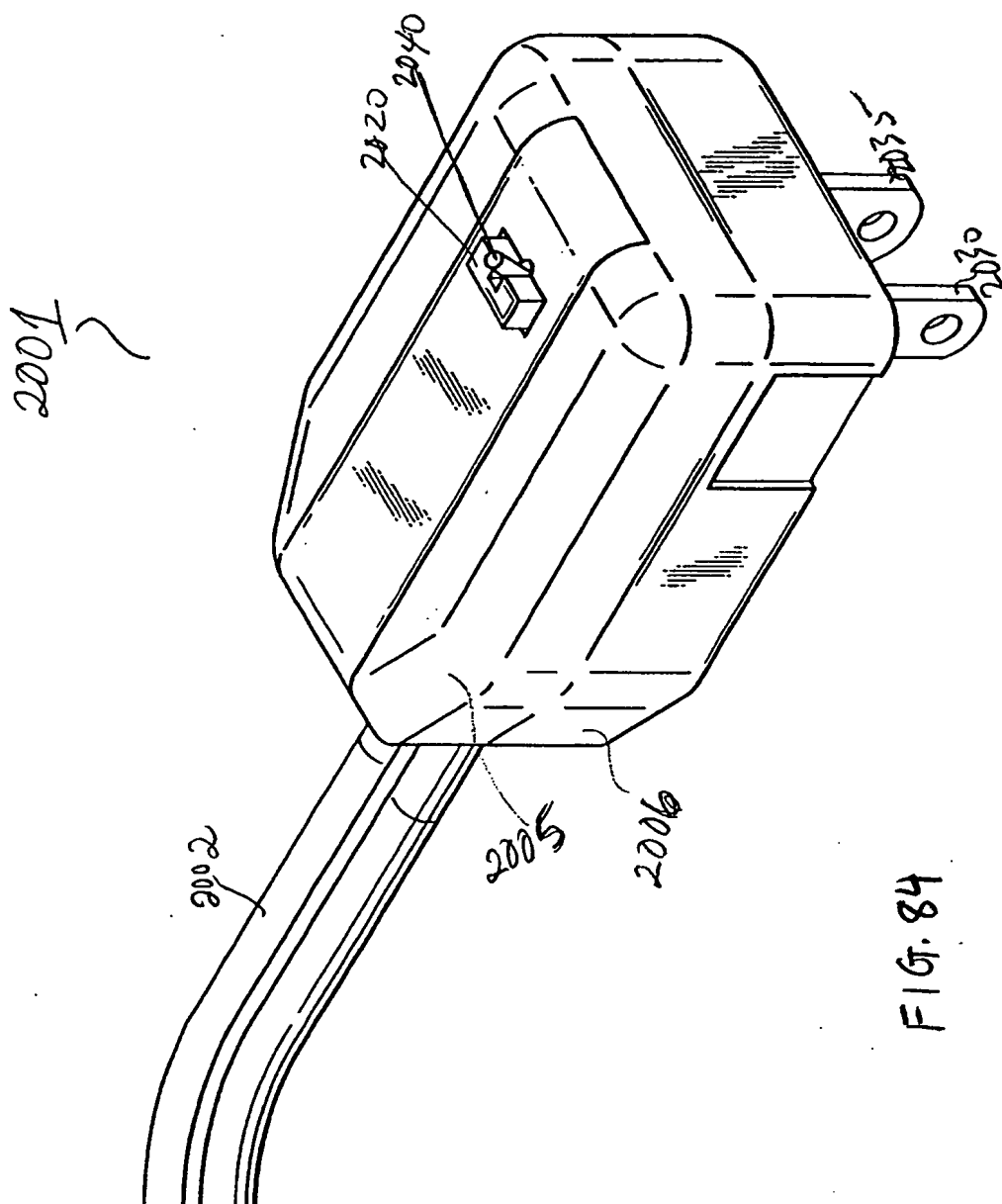
Bottom View Latched

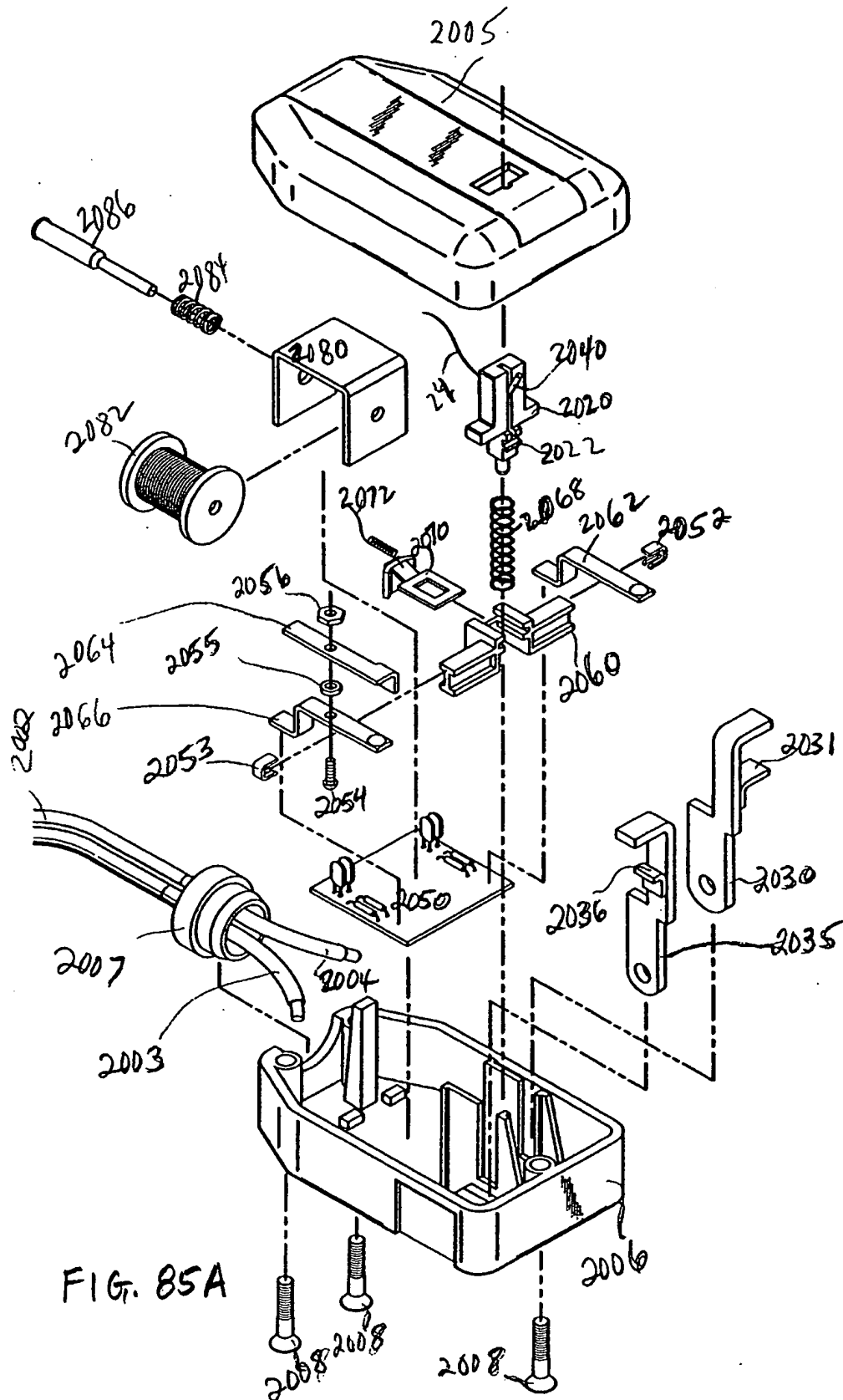


Spring catches Bridge
Guide Pin after trip

Fig. 82







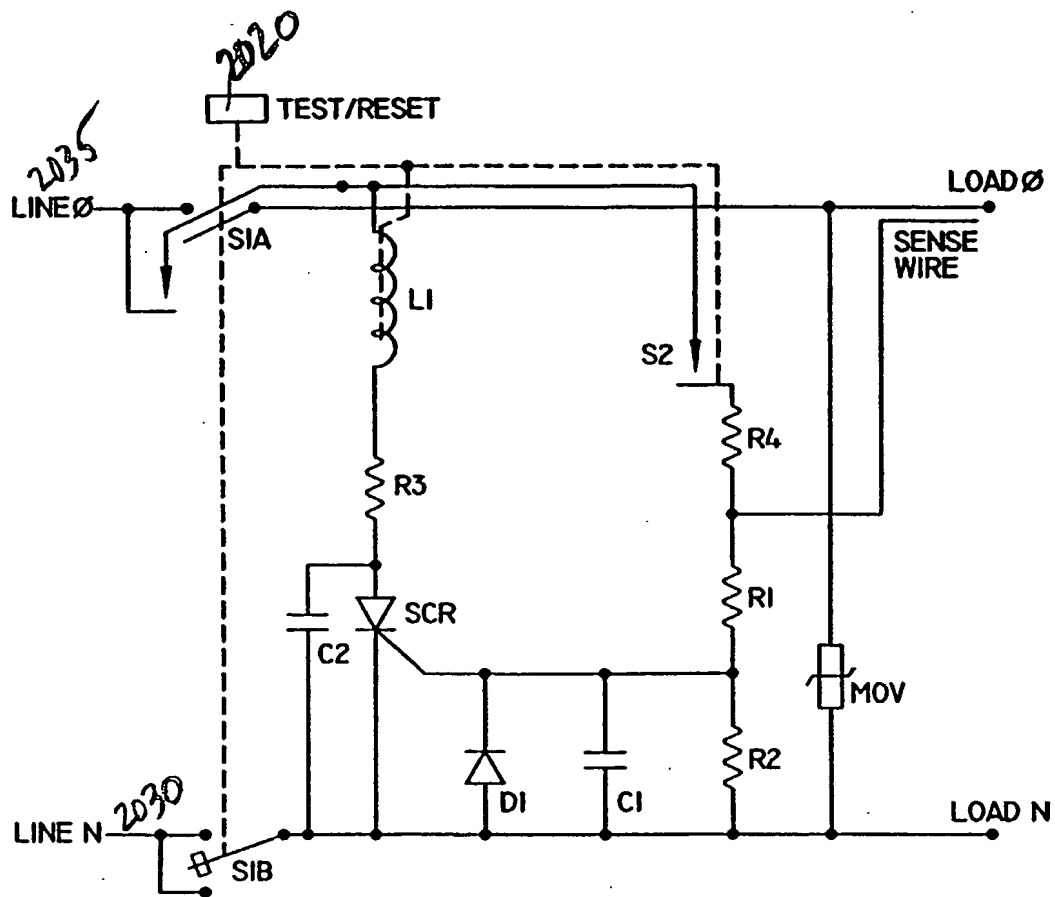
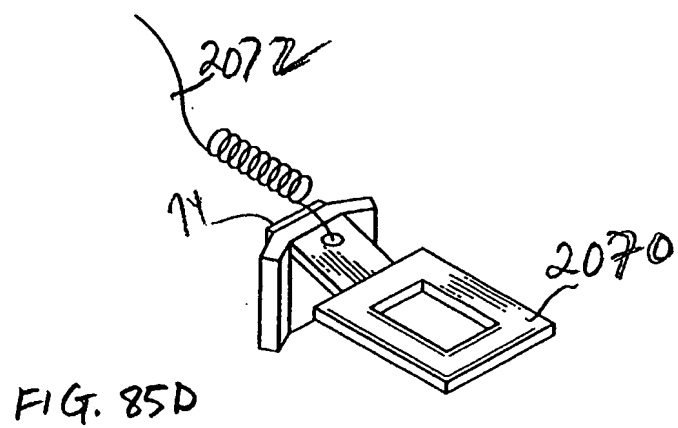
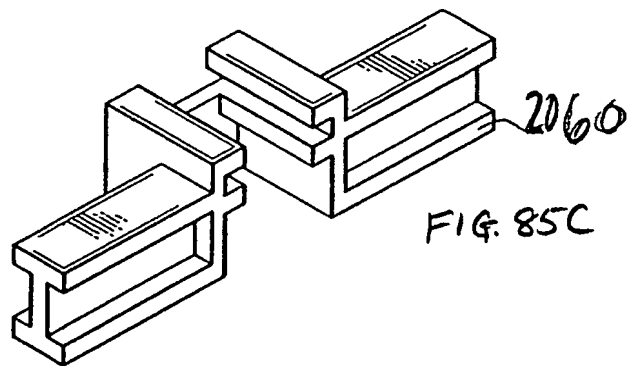
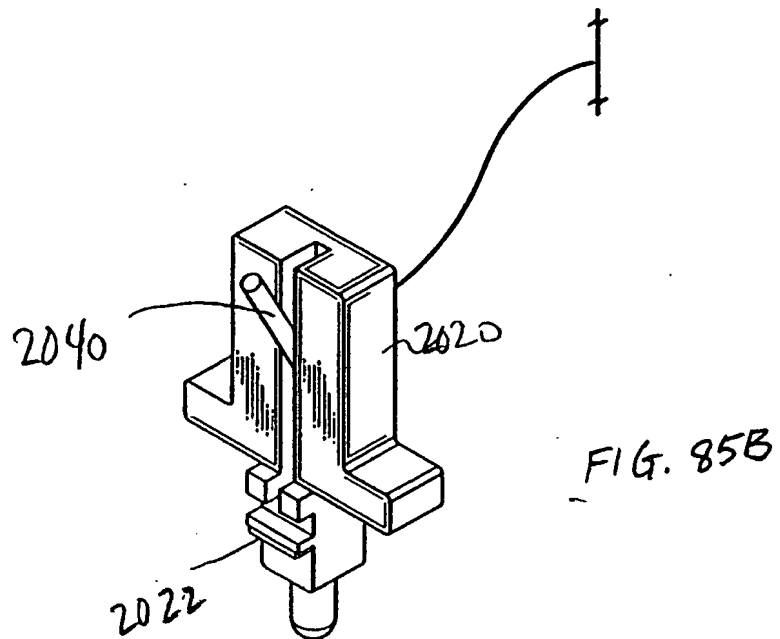
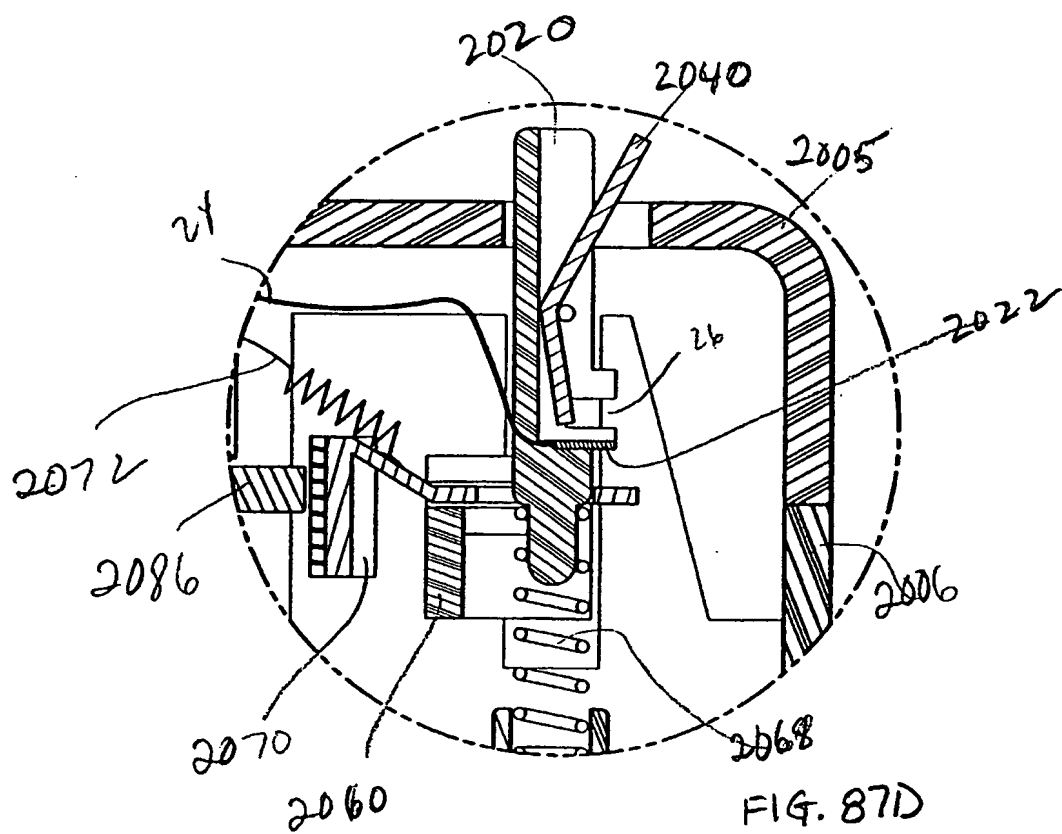
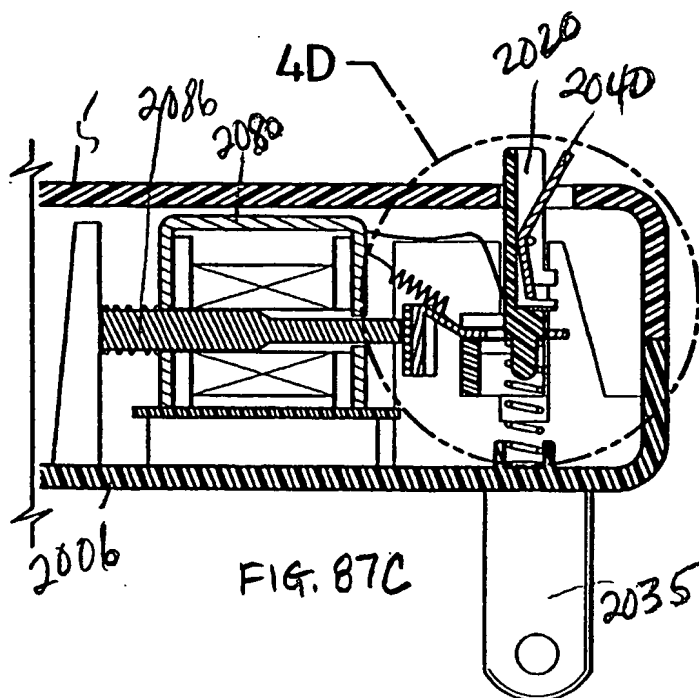


FIG. 85





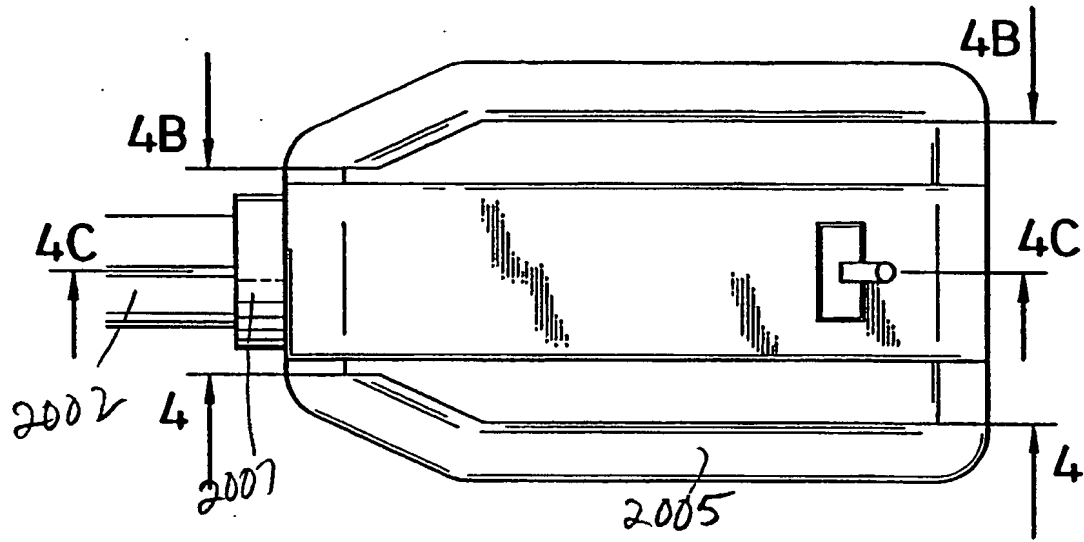


FIG. 86

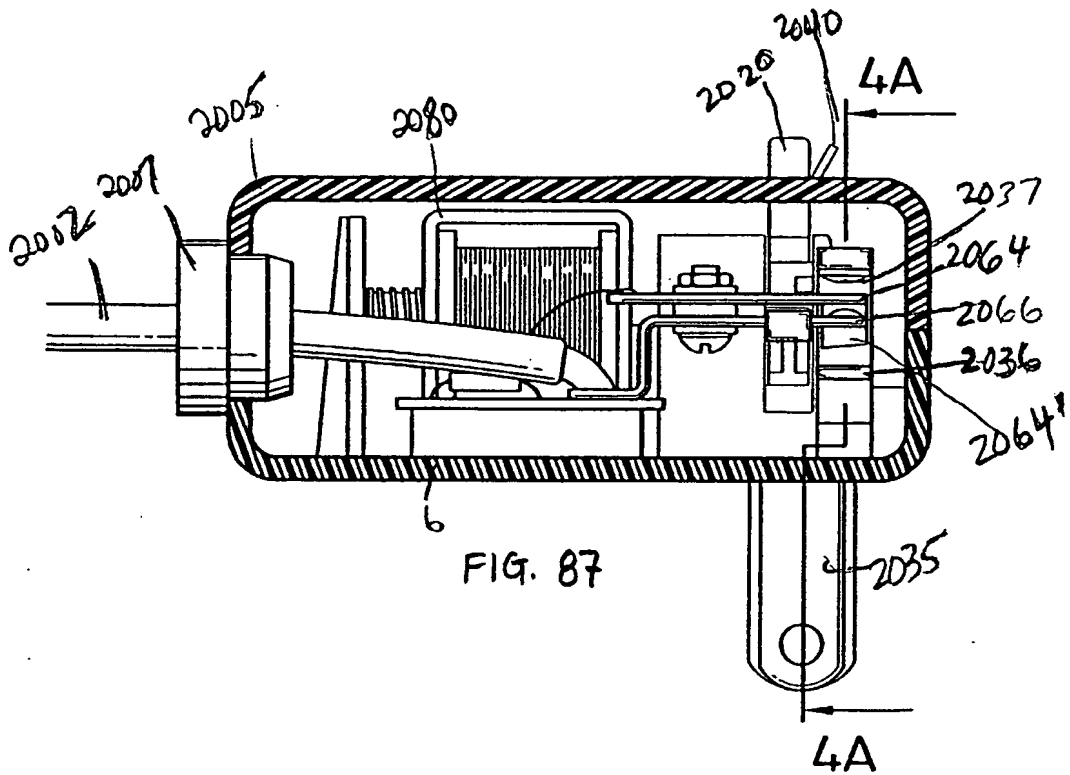


FIG. 87

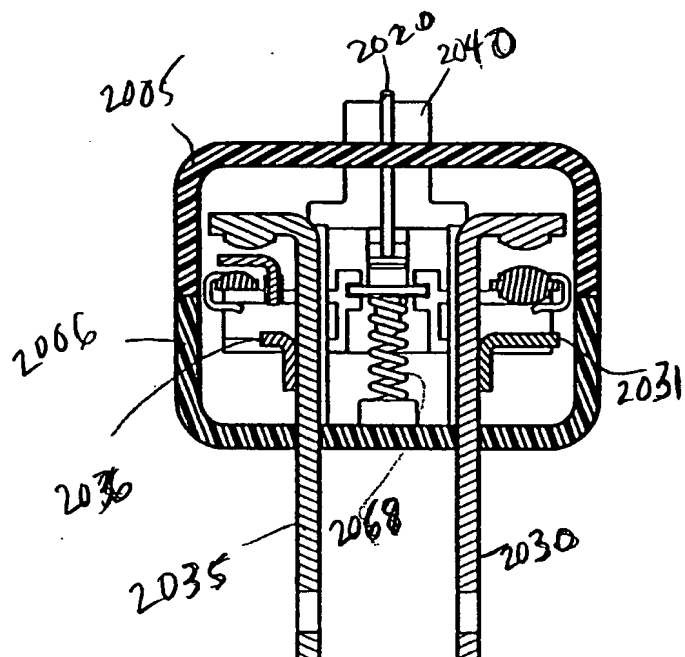


FIG. 87A

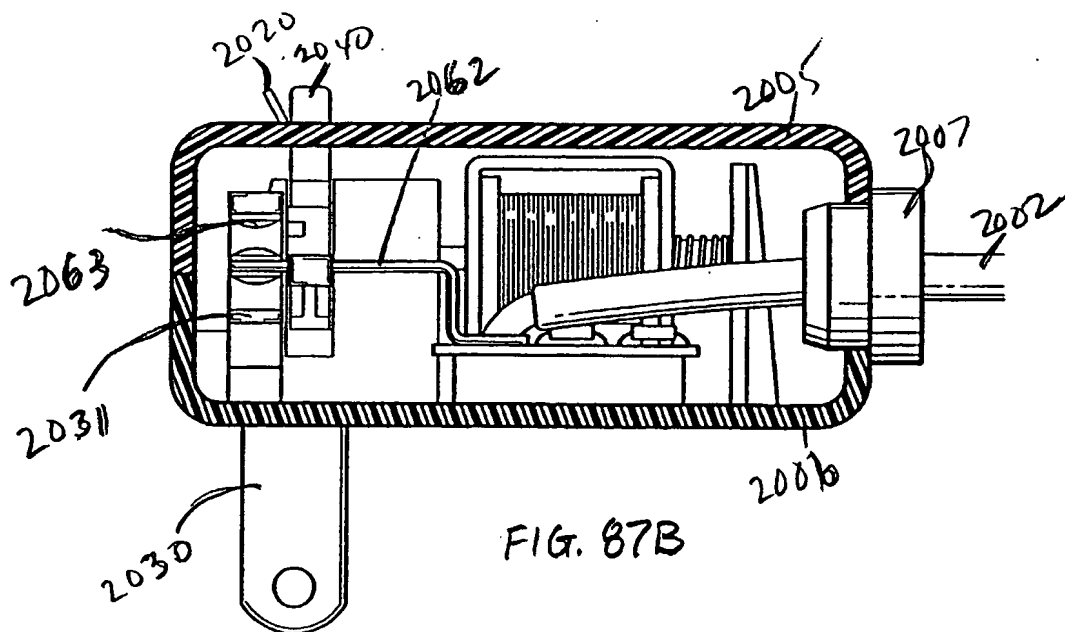
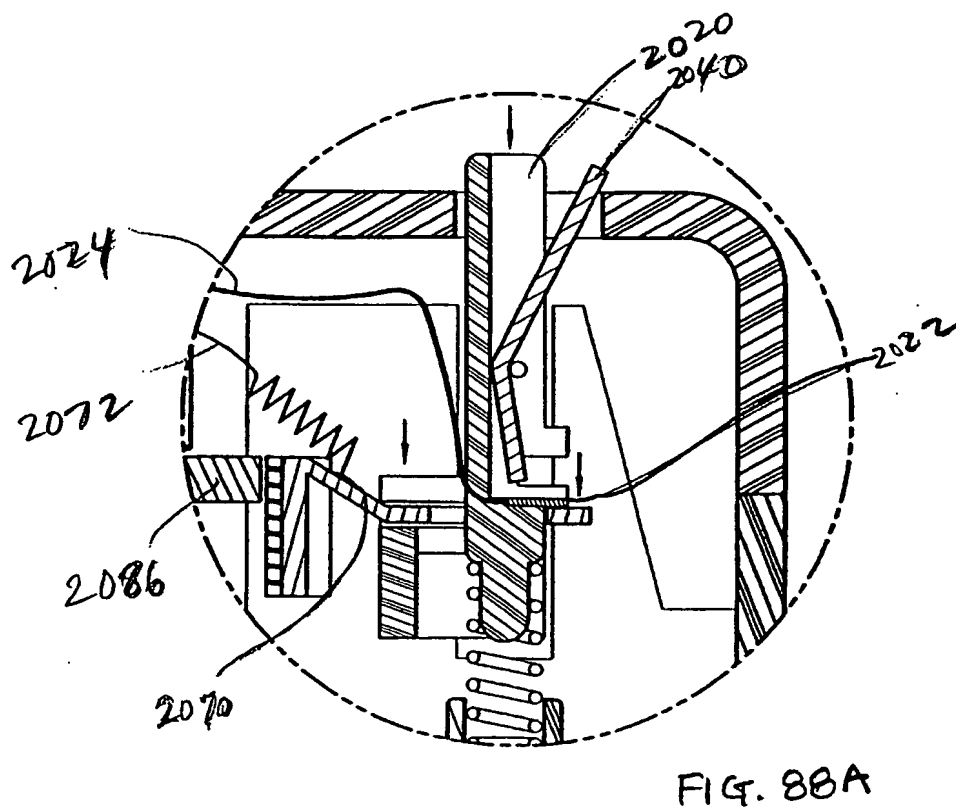
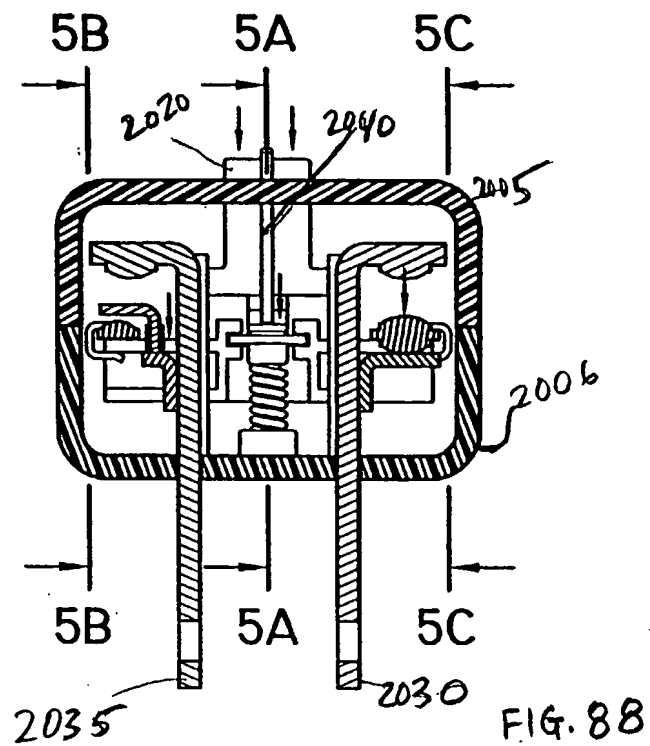
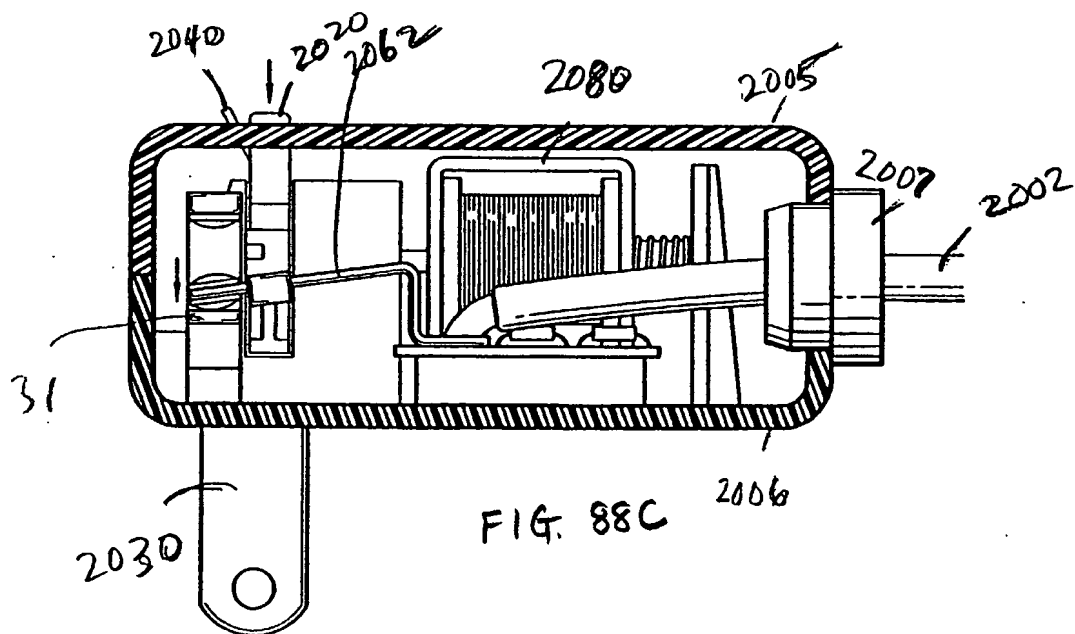
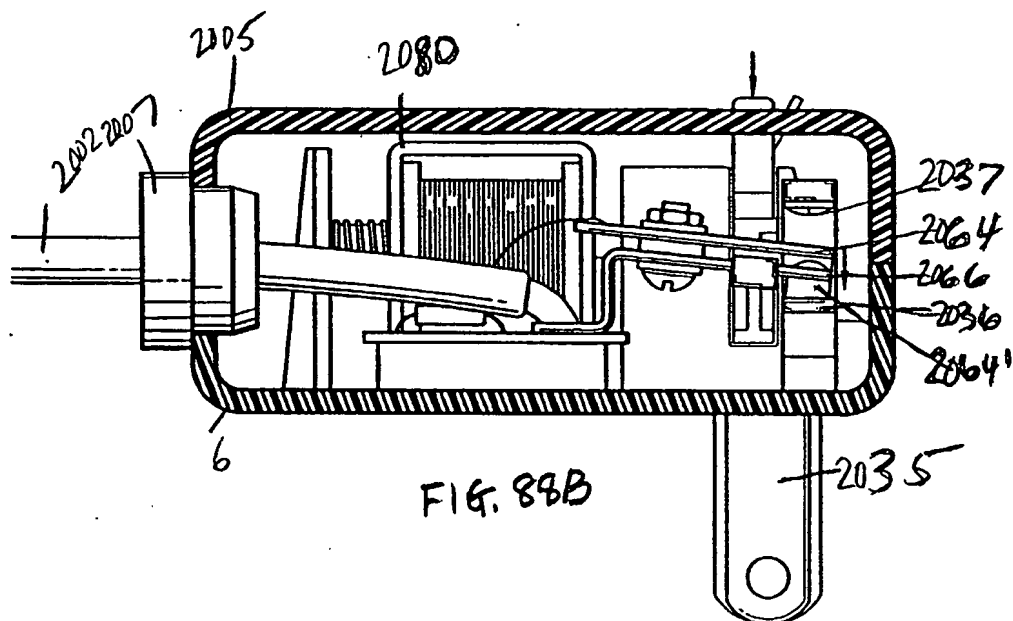
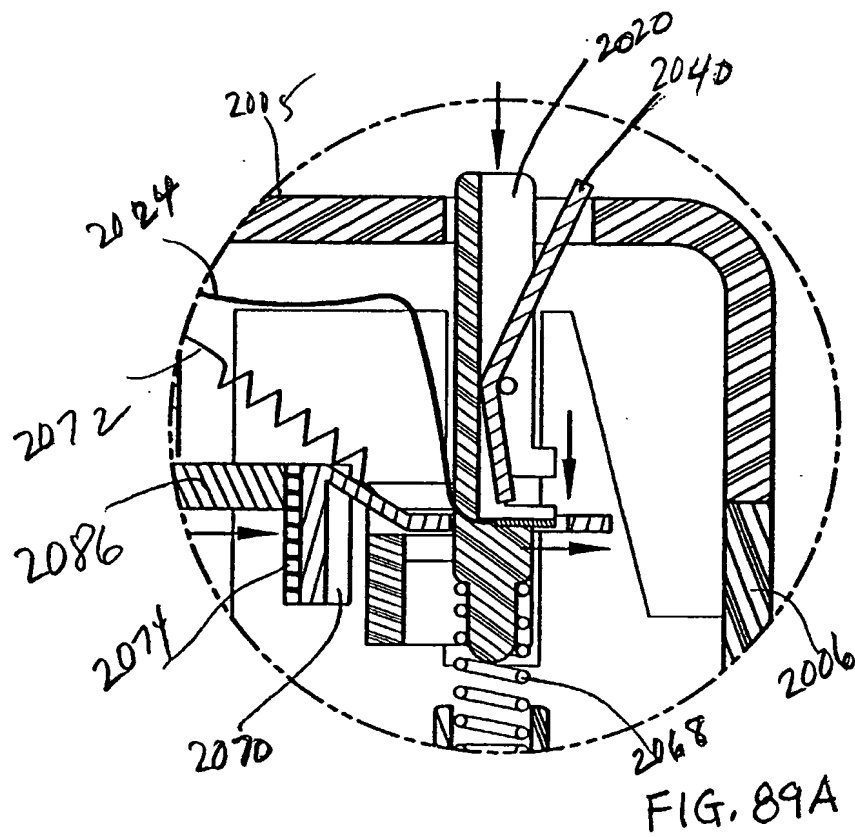
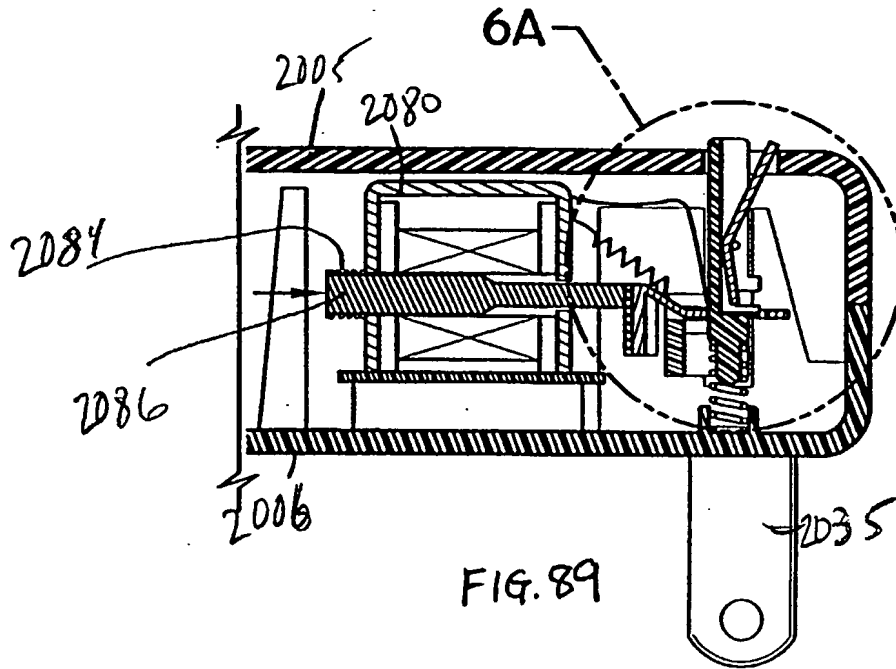
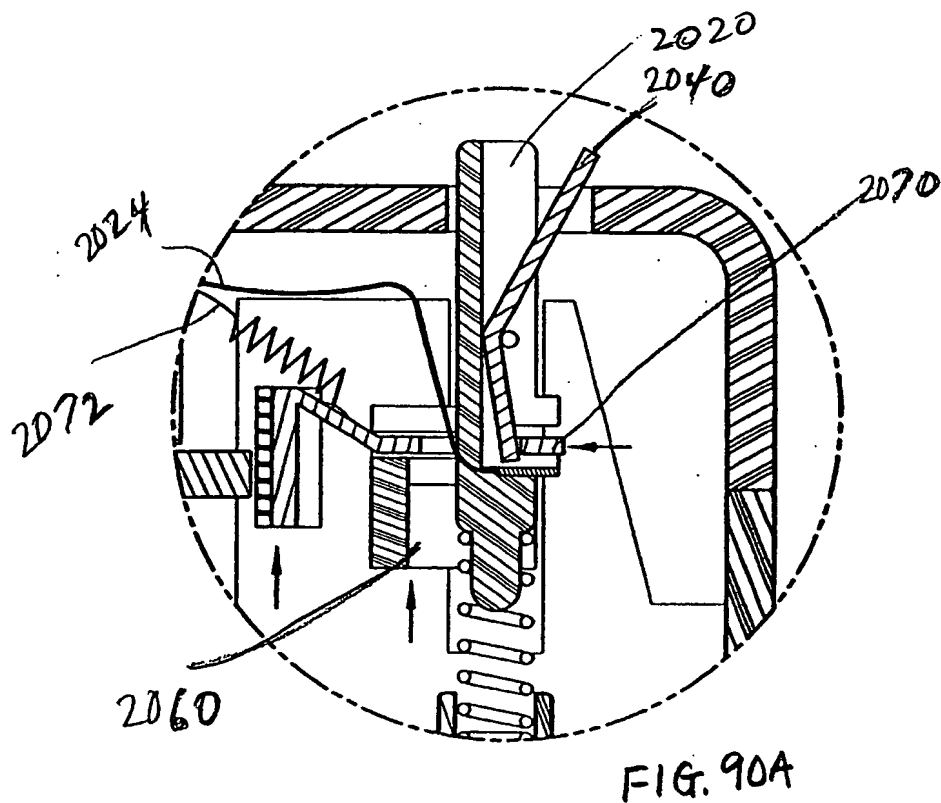
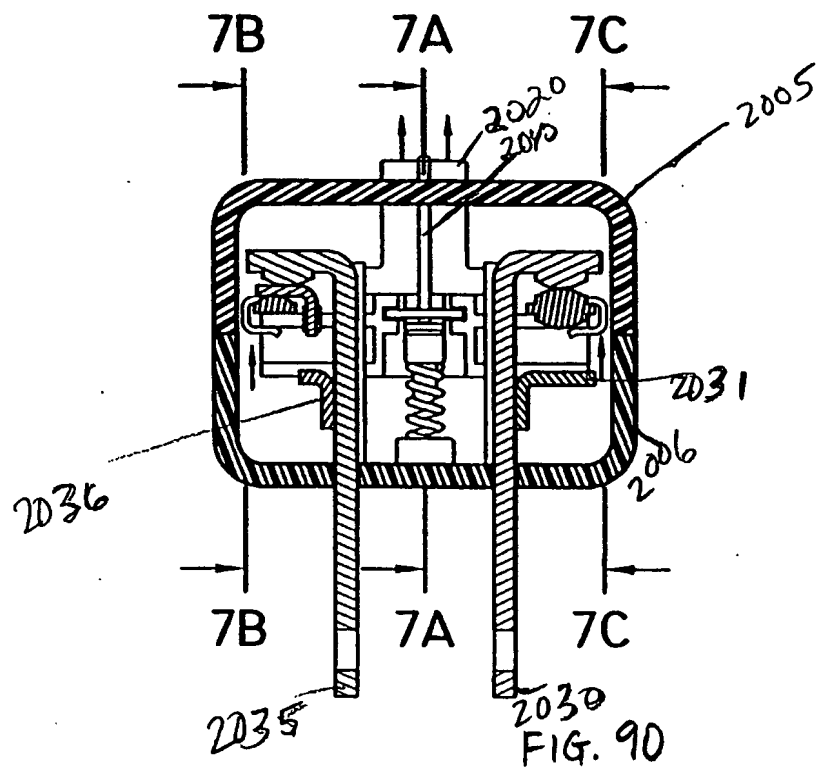


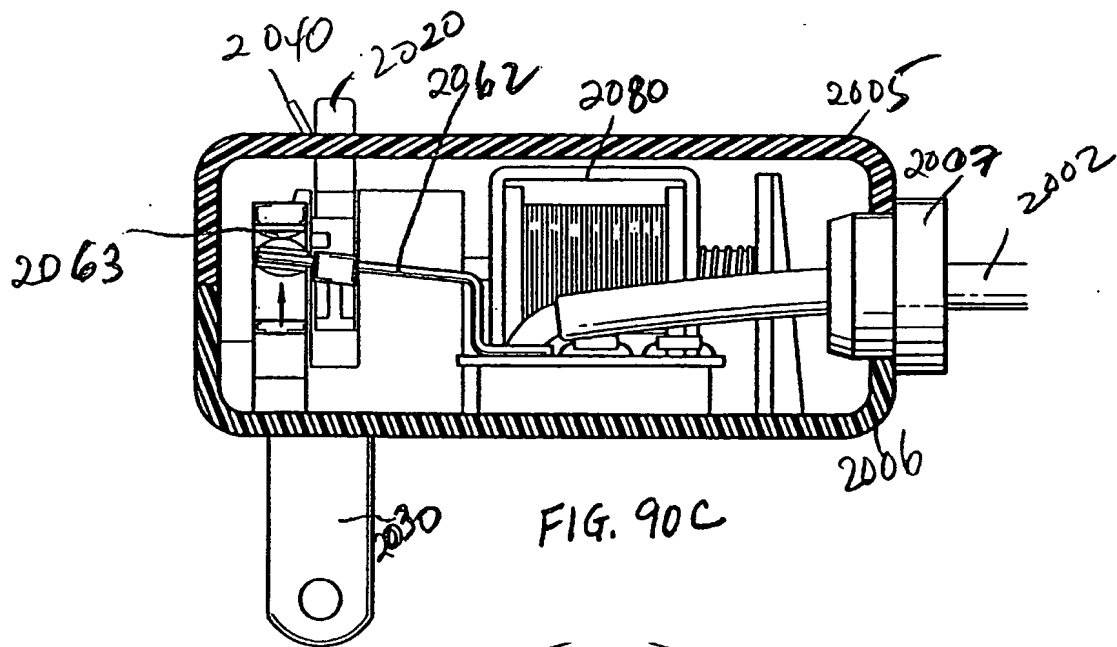
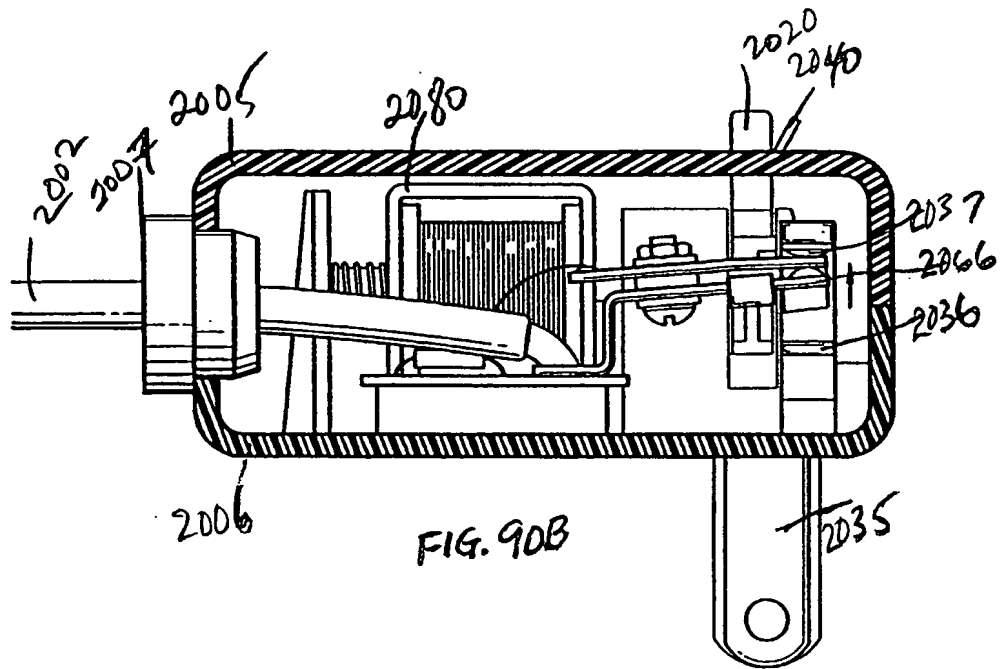
FIG. 87B











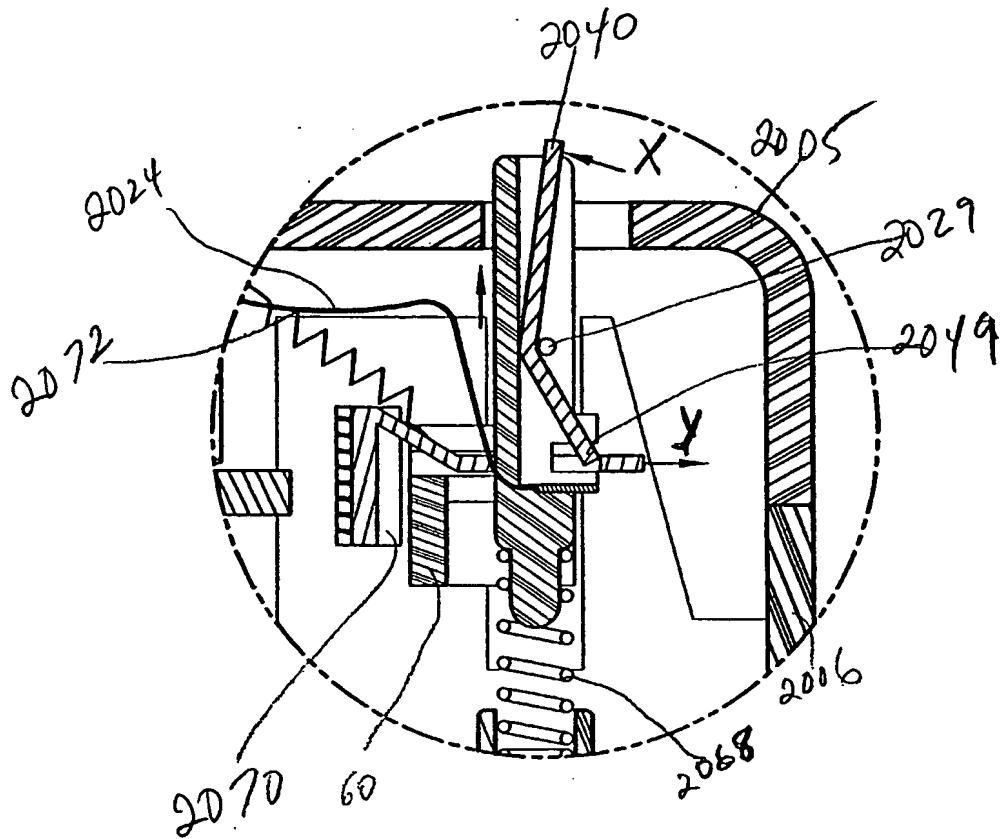


FIG. 91

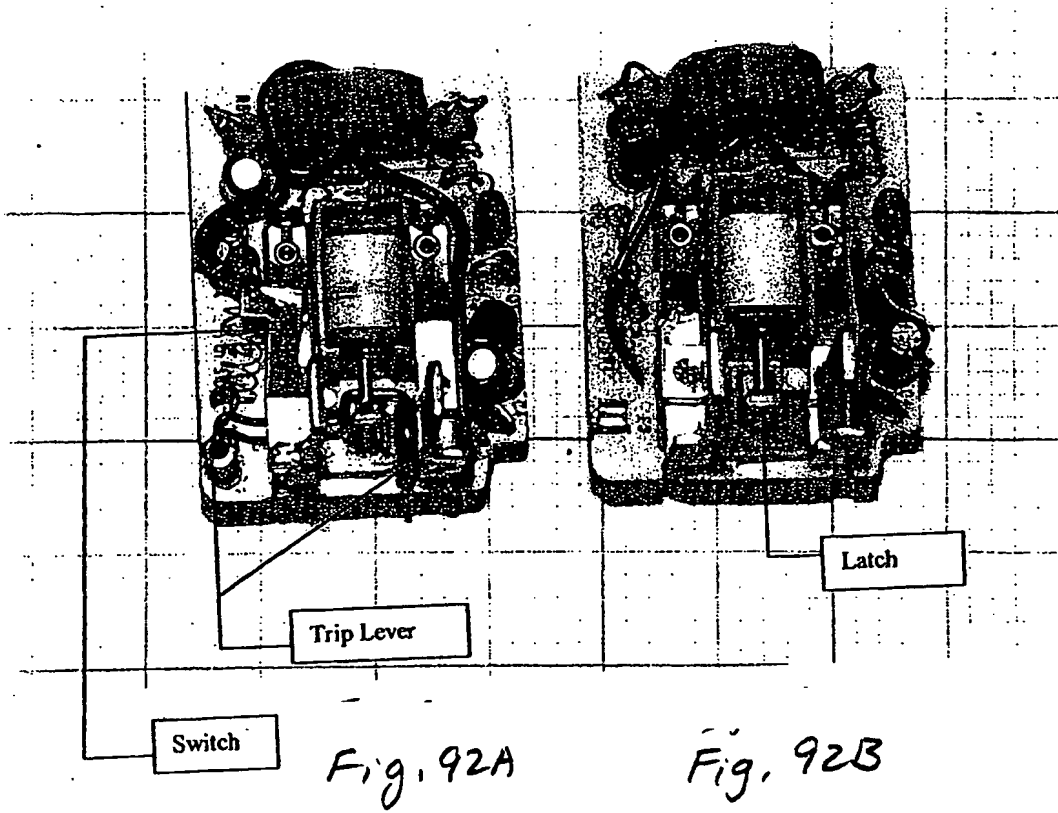


Fig 92C

Fig 92D

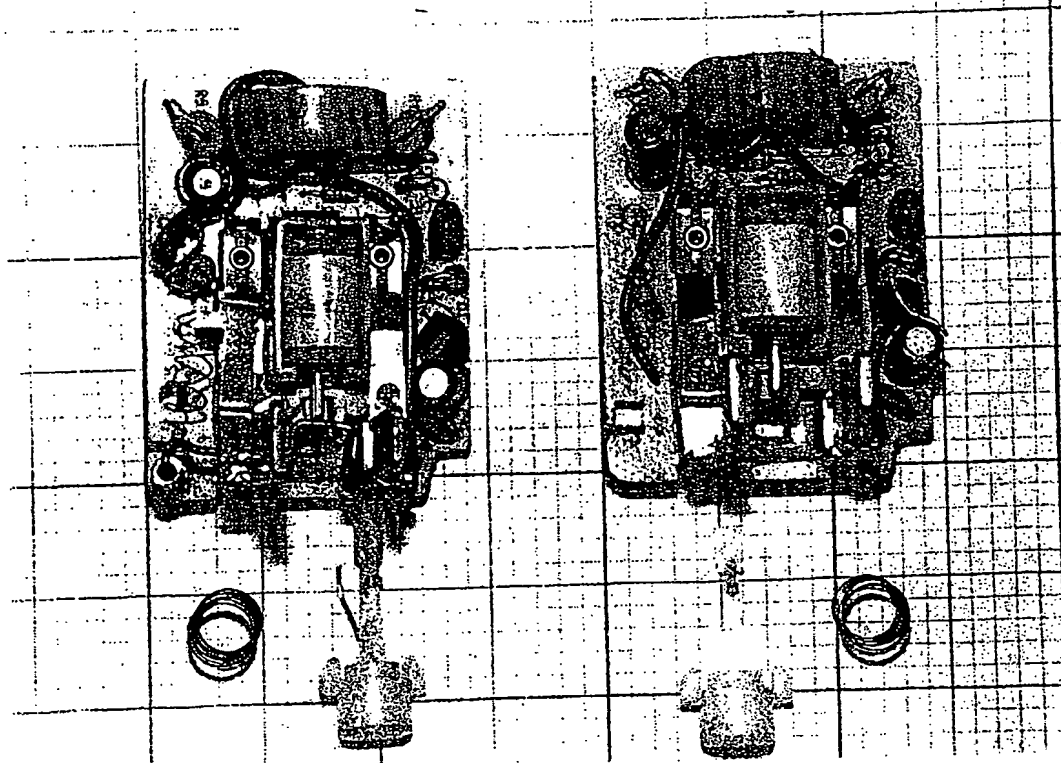


Fig 93a

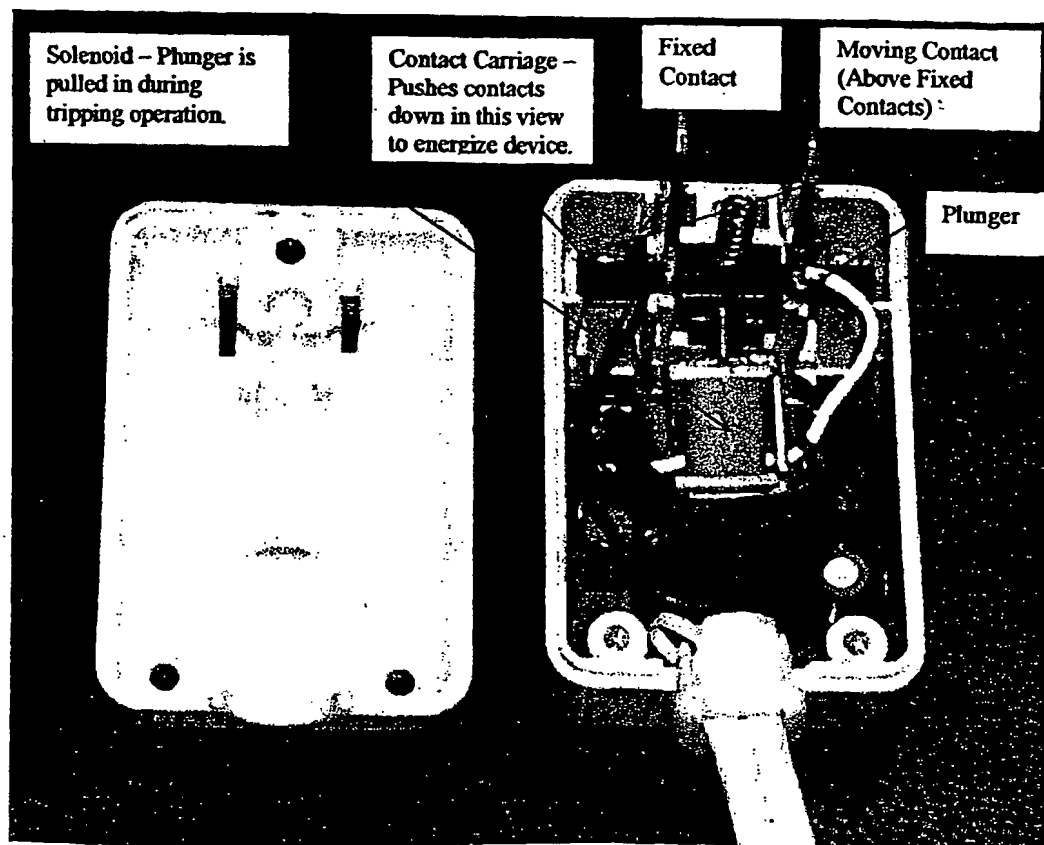


Fig. 93b

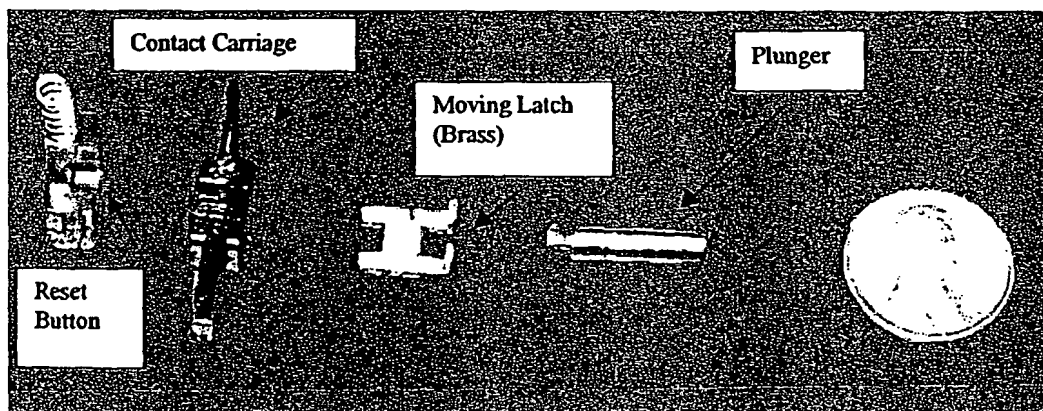


Fig 93c



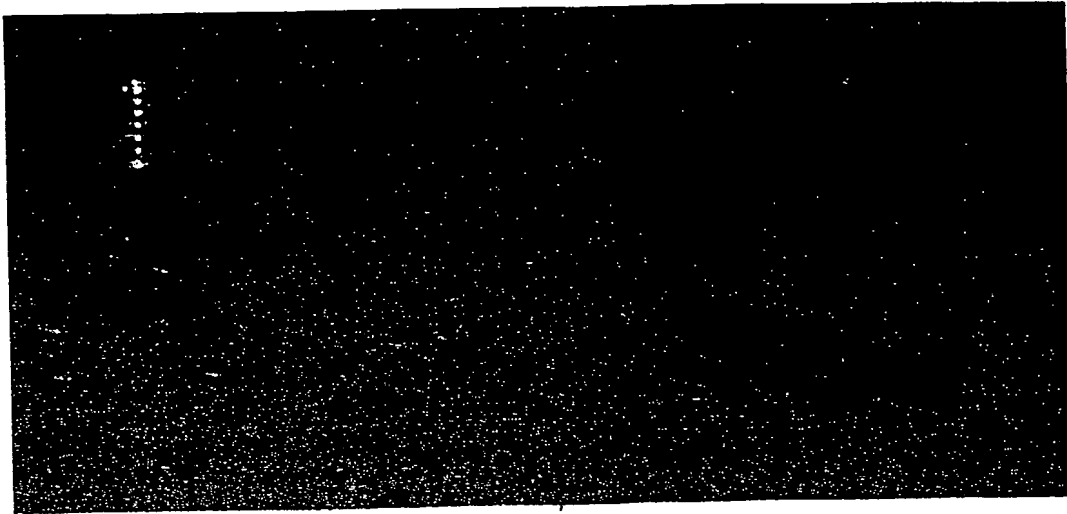


Fig. 93d

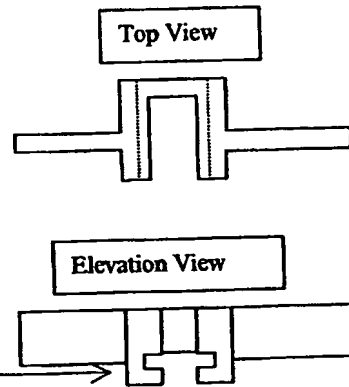
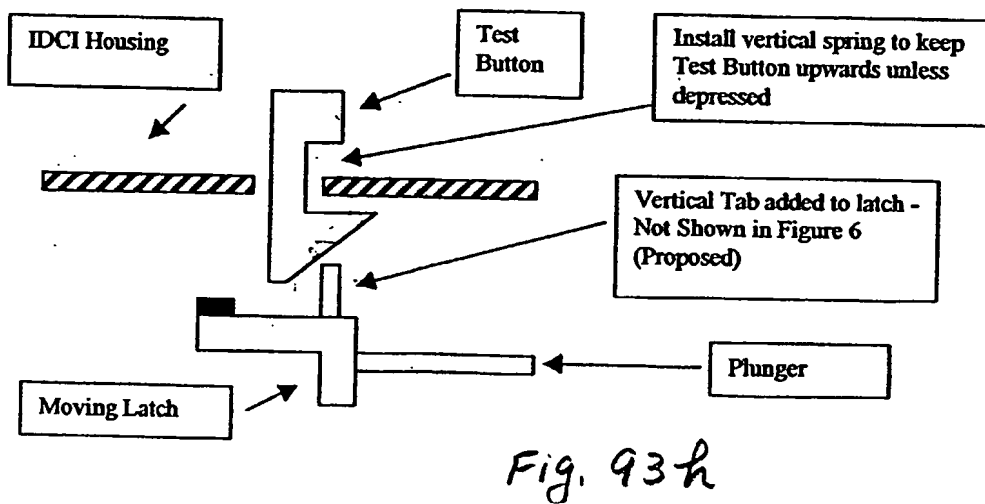
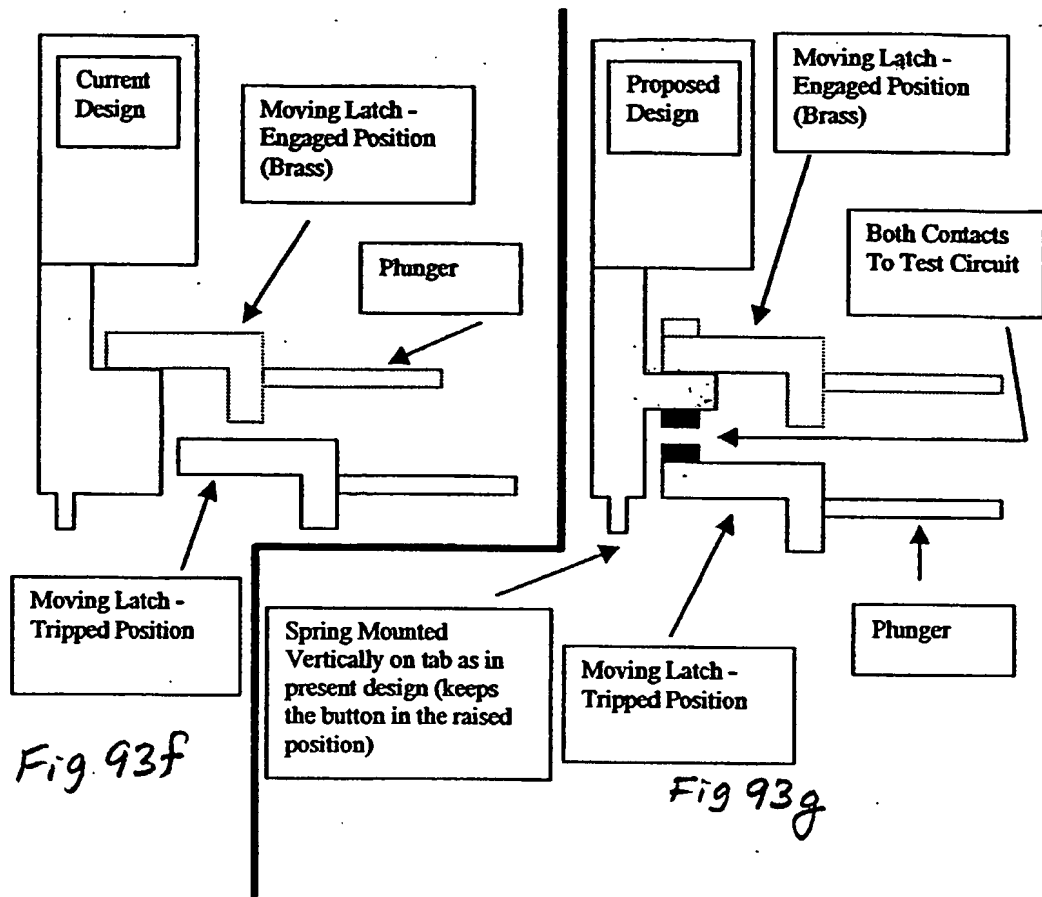
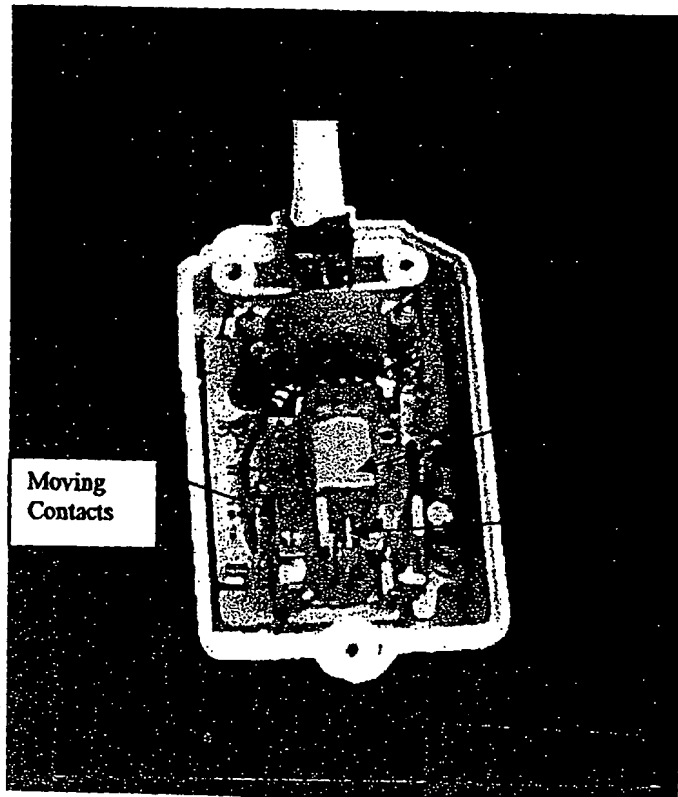


Fig 93e



194a



Moving
Contacts

Solenoid

Plunger - Pushes
out during
Solenoid operation

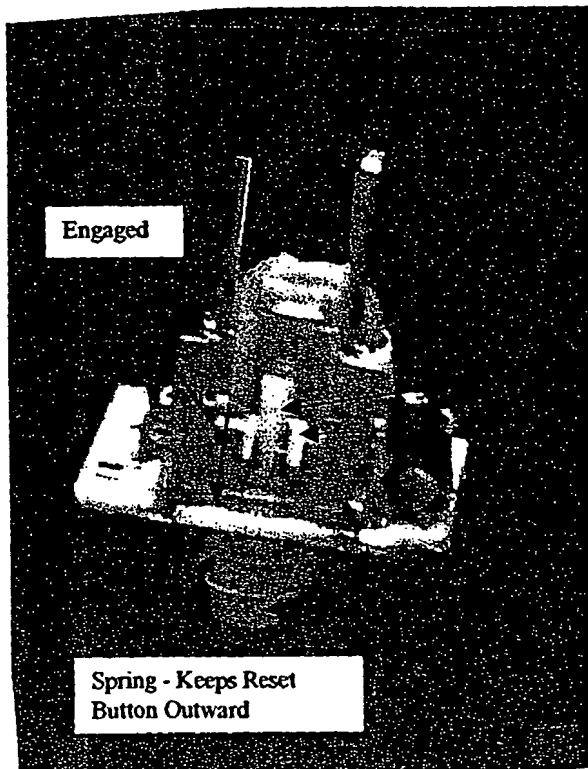


Fig. 94b

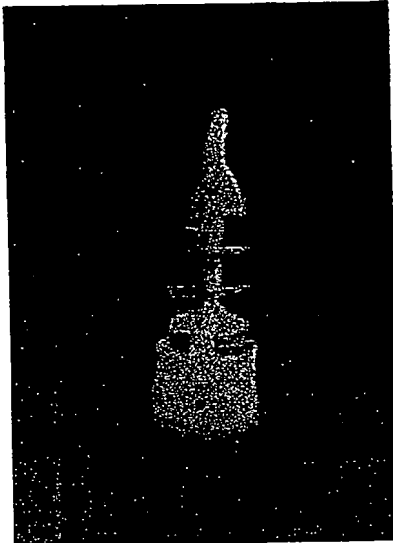
Engaged

Reset Button - (Bottom -
Engages with Contact Carriage)

Contact Carriage

Reset Button
(Top)

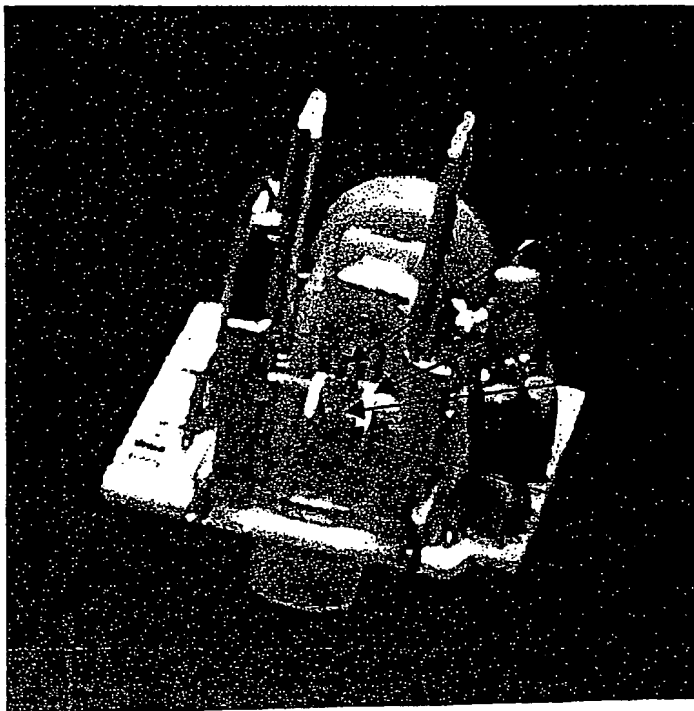
Spring - Keeps Reset
Button Outward



When Reset button is pushed, this barb slides past and engages with the step of the Contact Carriage and moves the Contact Carriage to close the contacts and pull the device on line.

This spring keeps the Reset button pushed outward (down in this view) and the contacts closed if the IDCI is online

g 94c



Plunger

Contact Carriage

This step on the Contact Carriage Engages with the barb on the Reset Button shown in Figure 3.

This surface is curved to allow the barb on the Reset button slide past and catch this step.

94d

94e

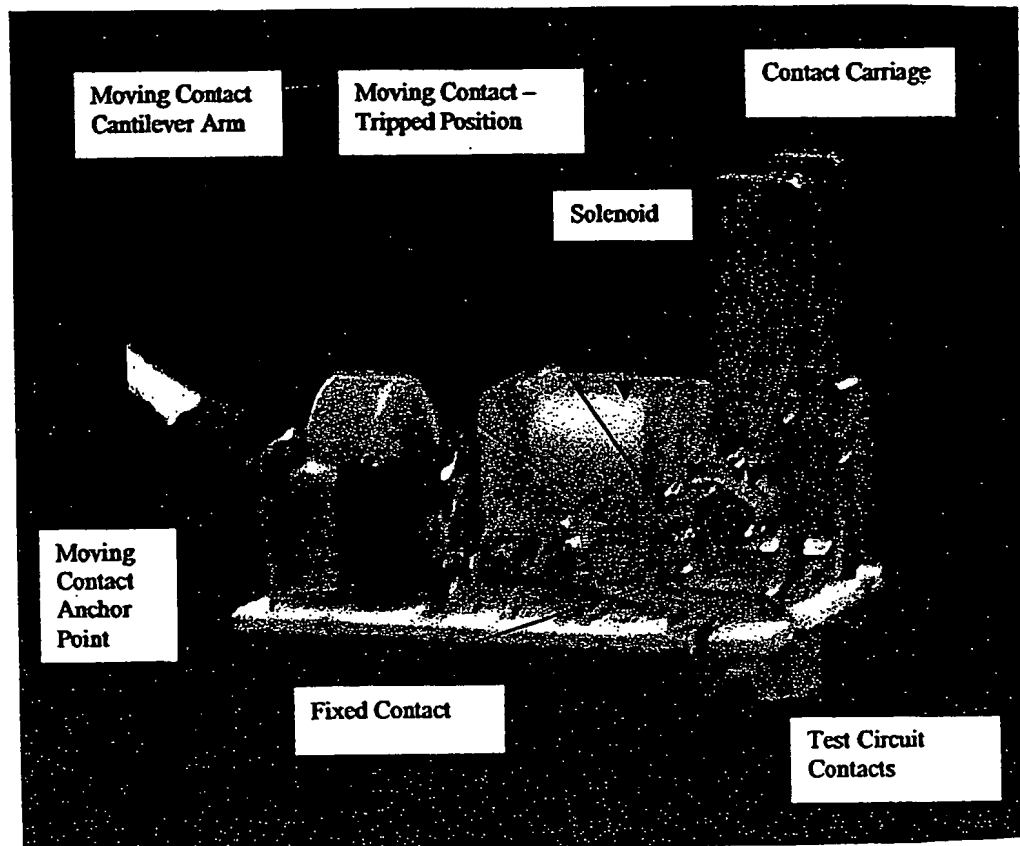
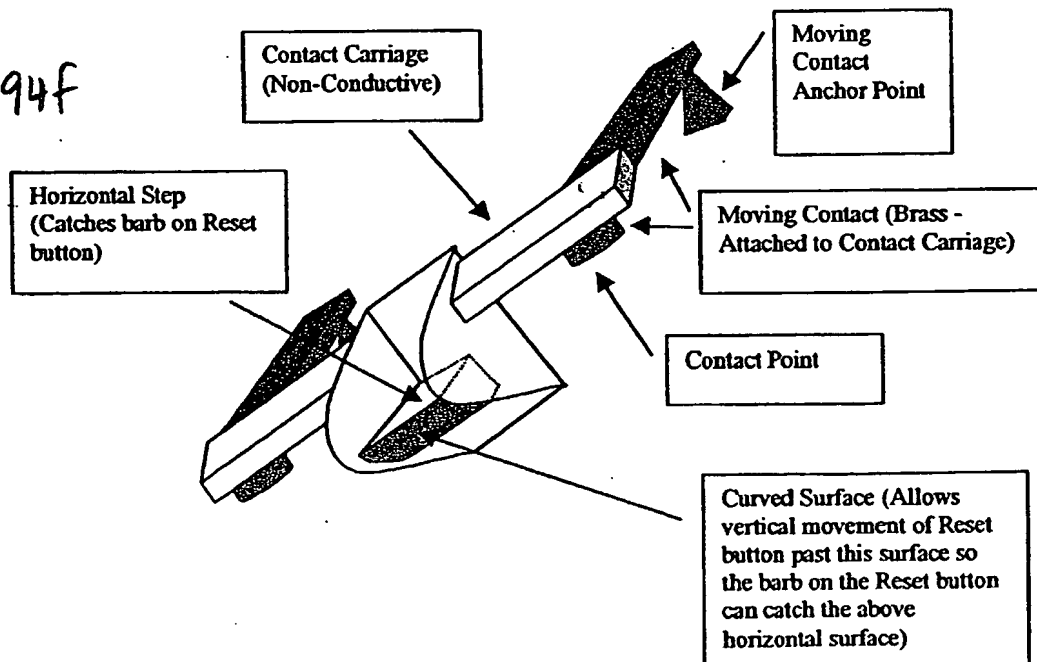


Fig. 94f



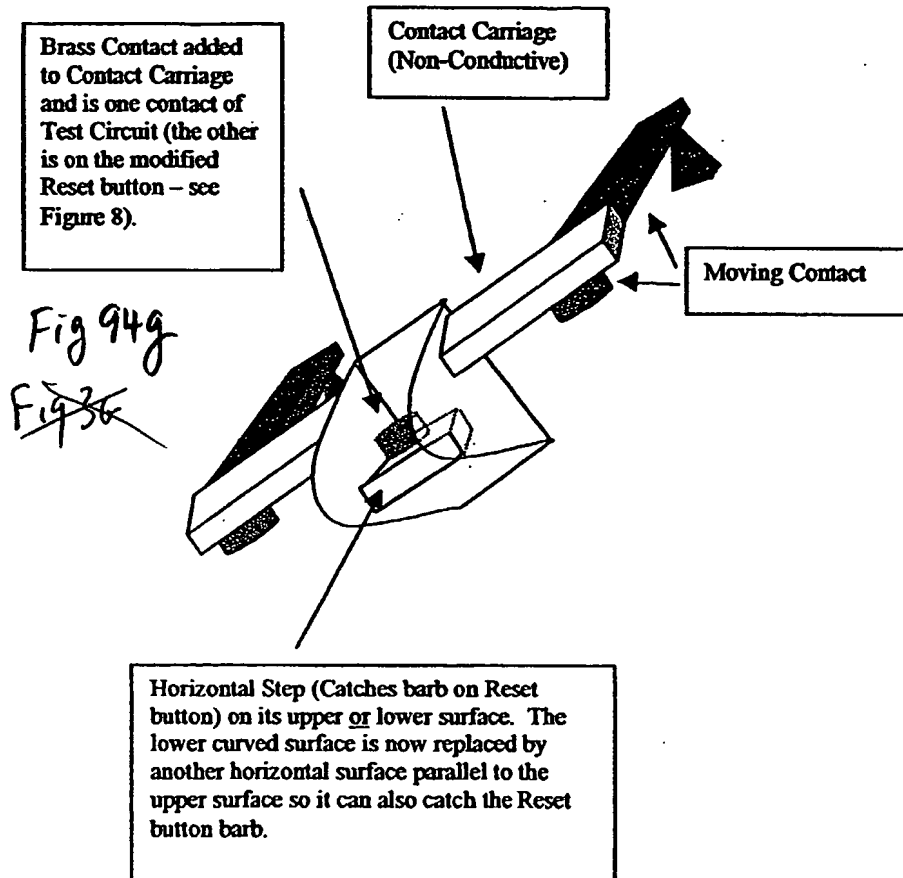
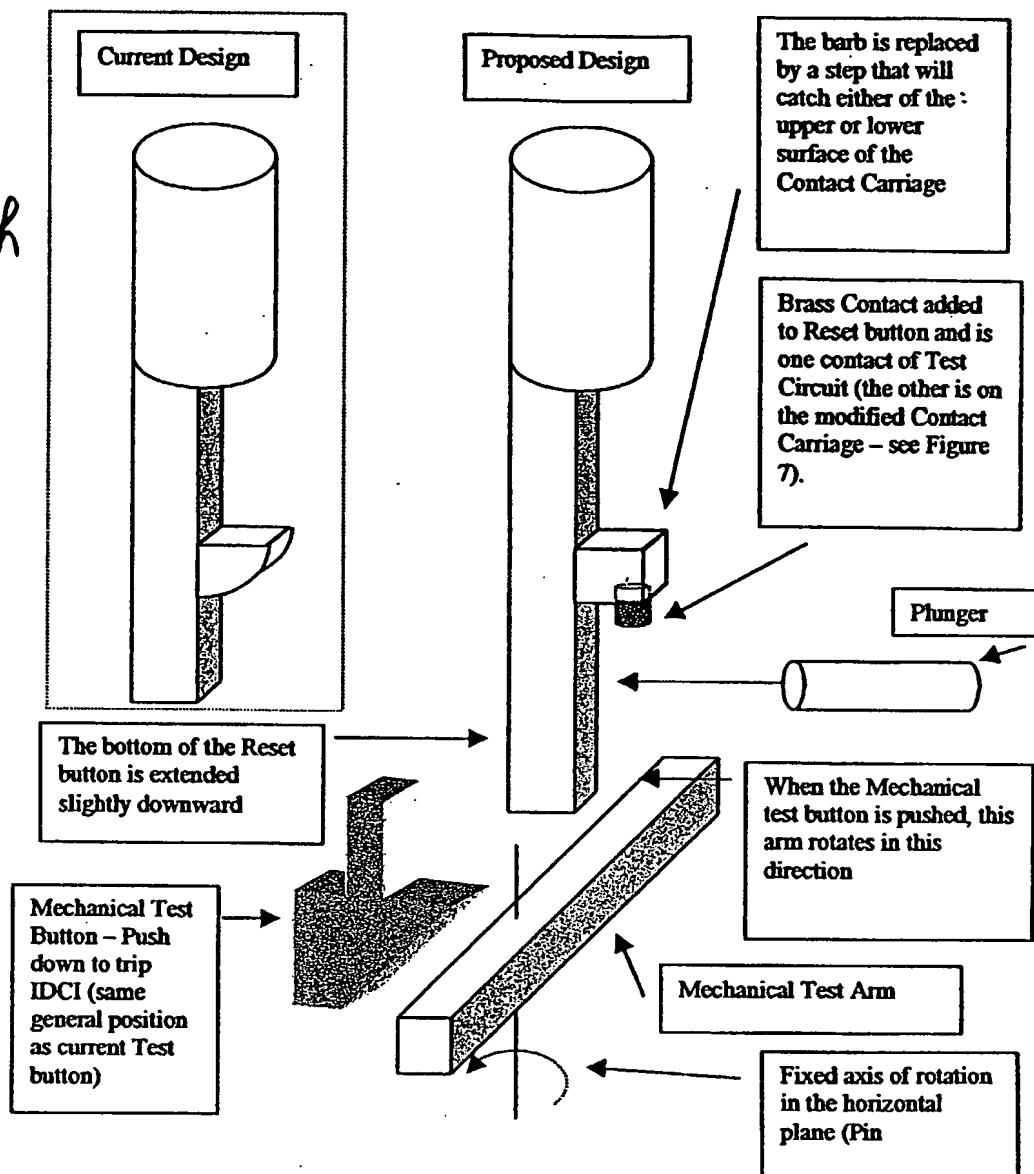


Fig. 94R



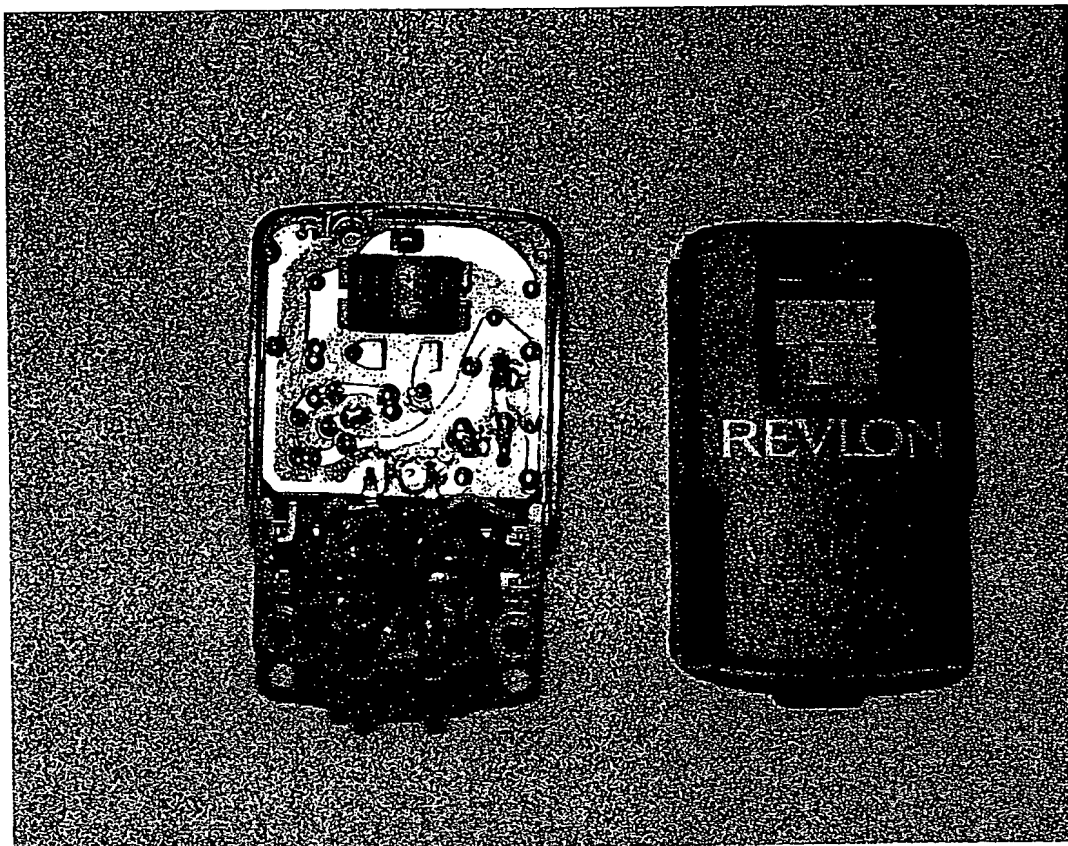


Fig 95a

Fig. 95b

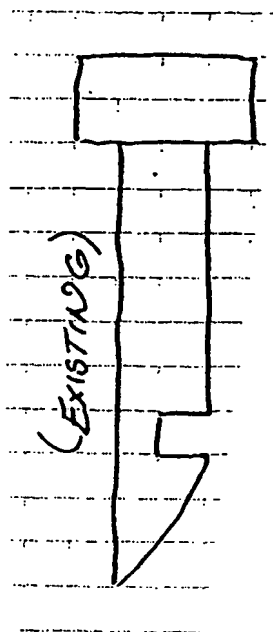
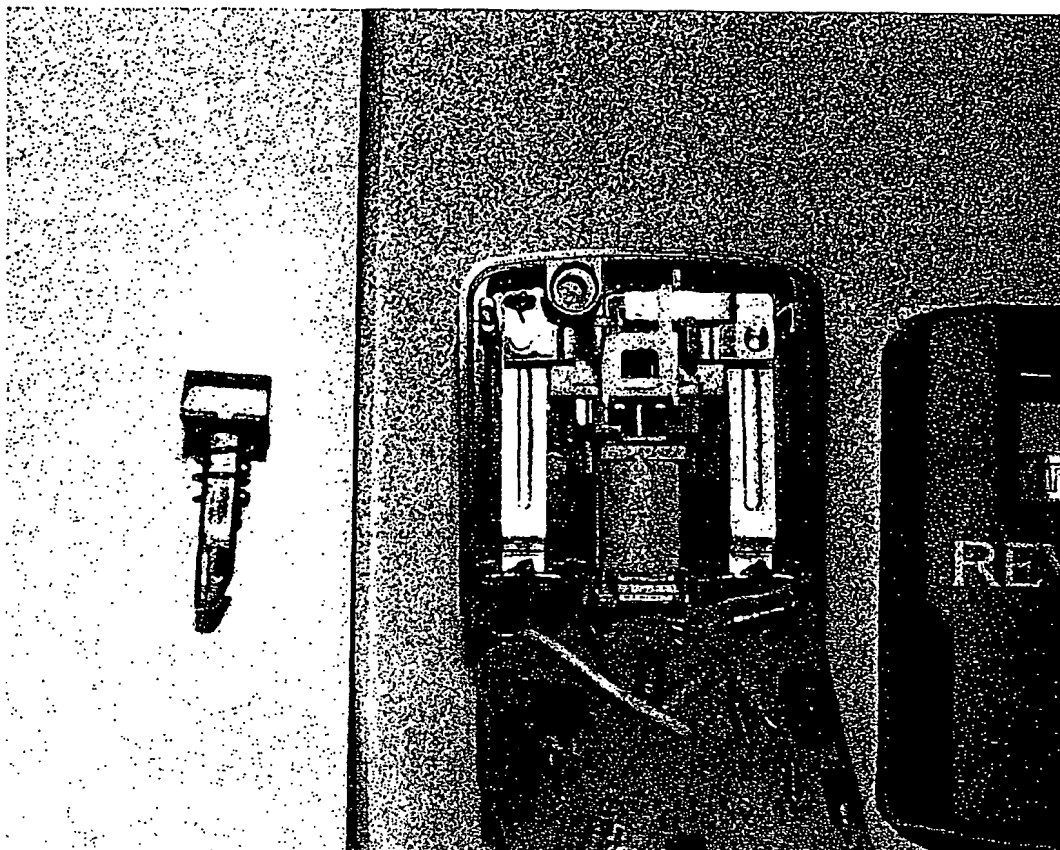
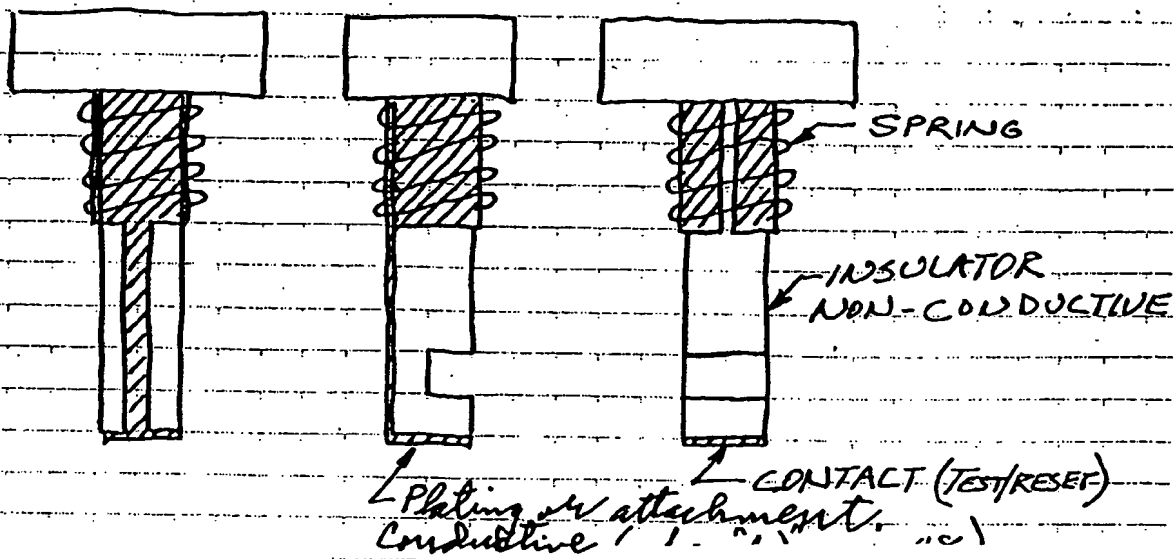
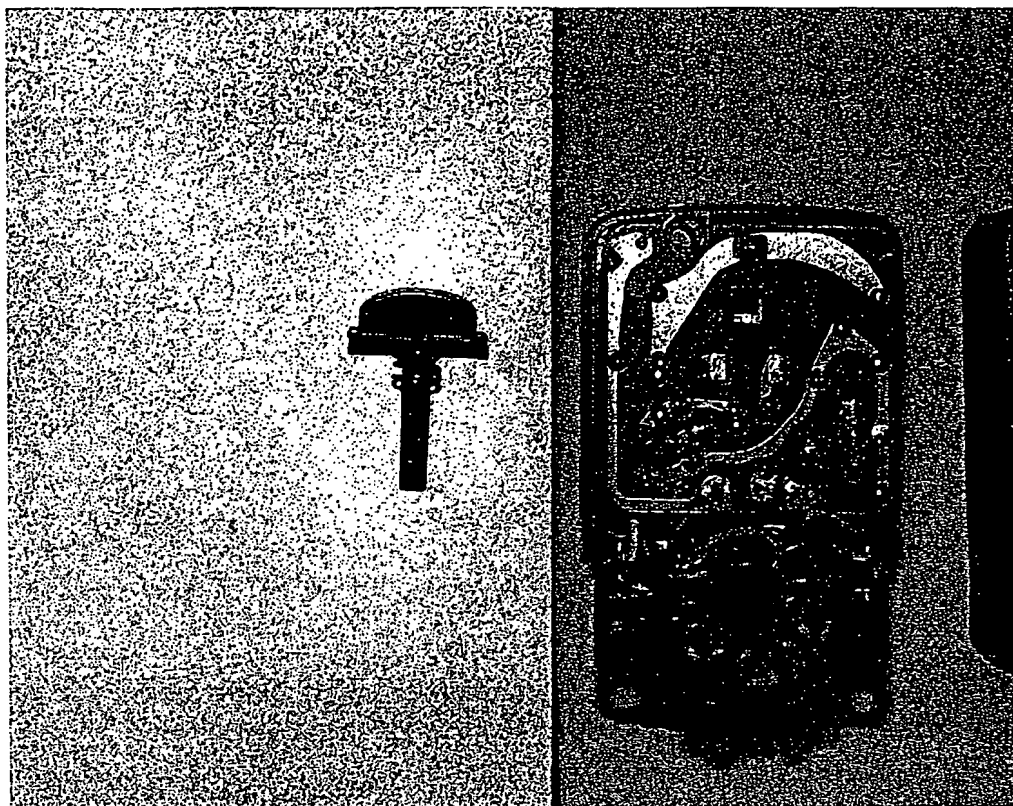


Fig 95c



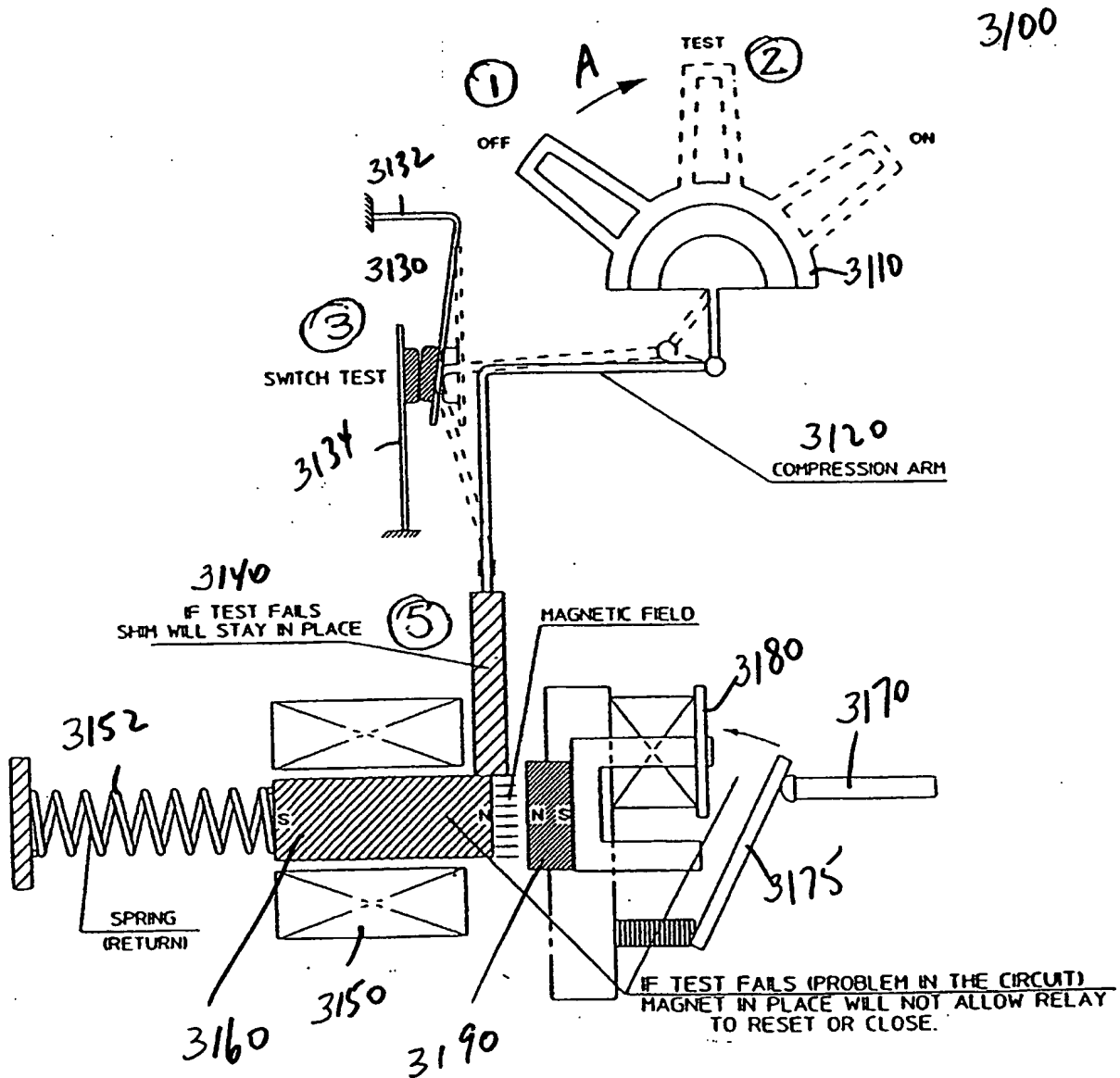


Fig. 96

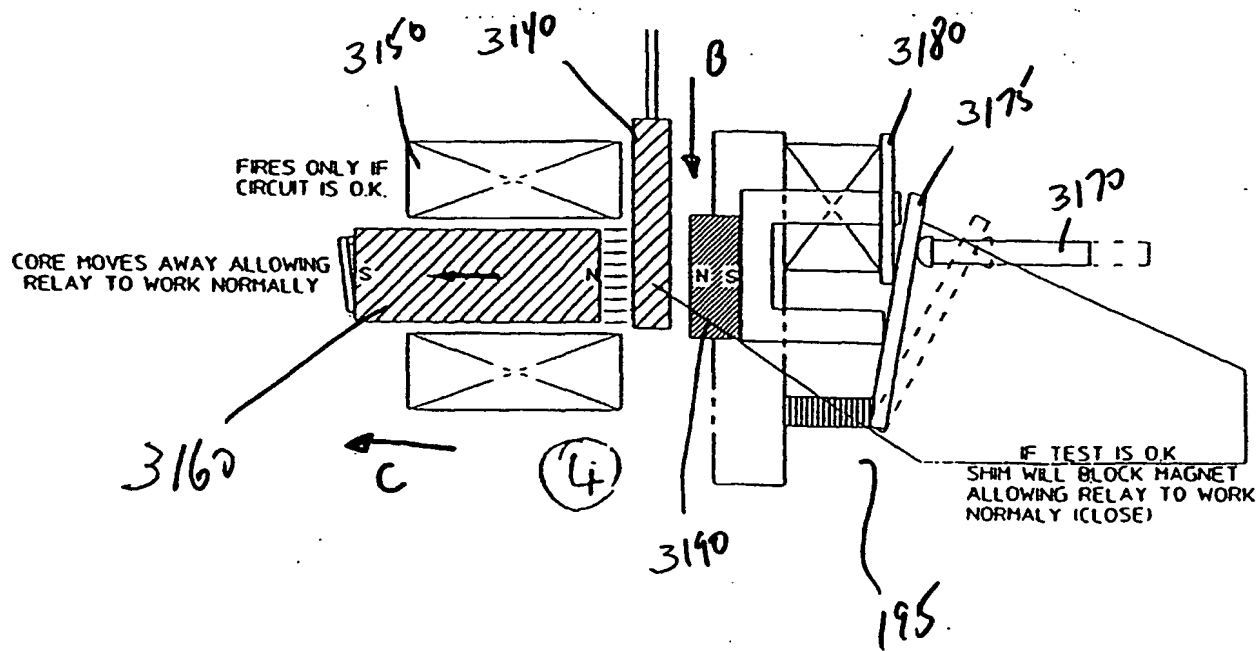


Fig. 97

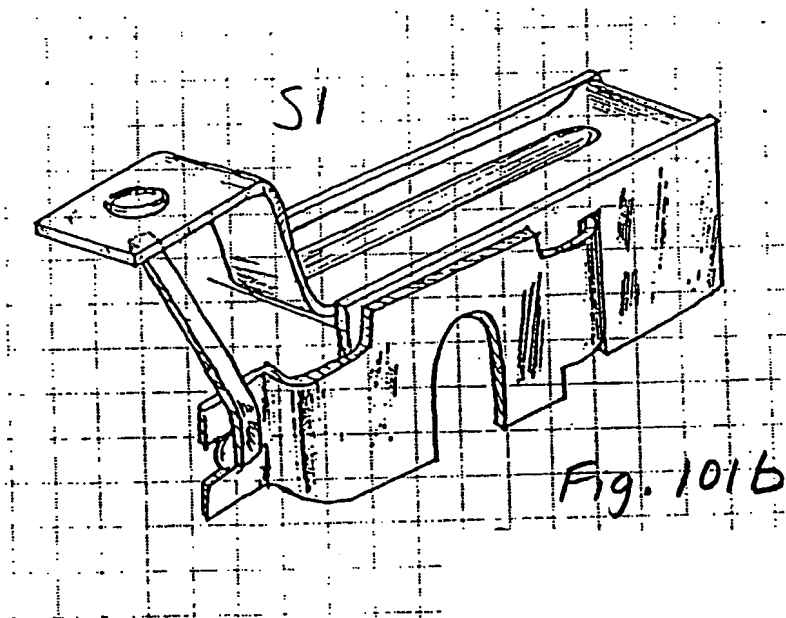
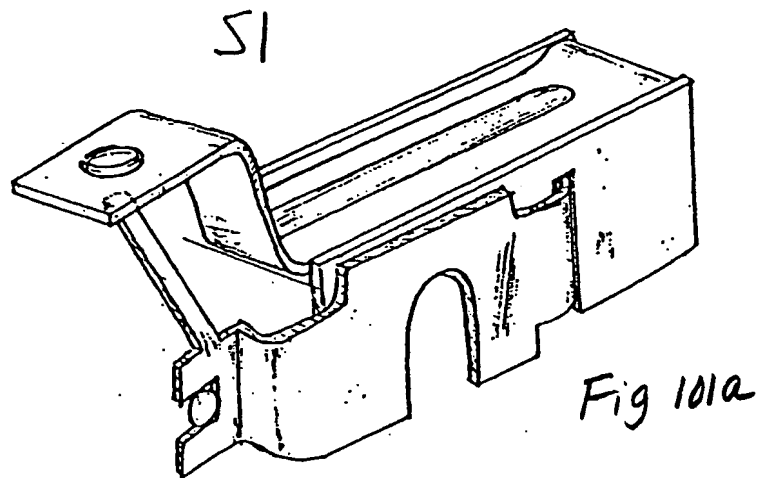


FIG. 102 (PRIOR ART)

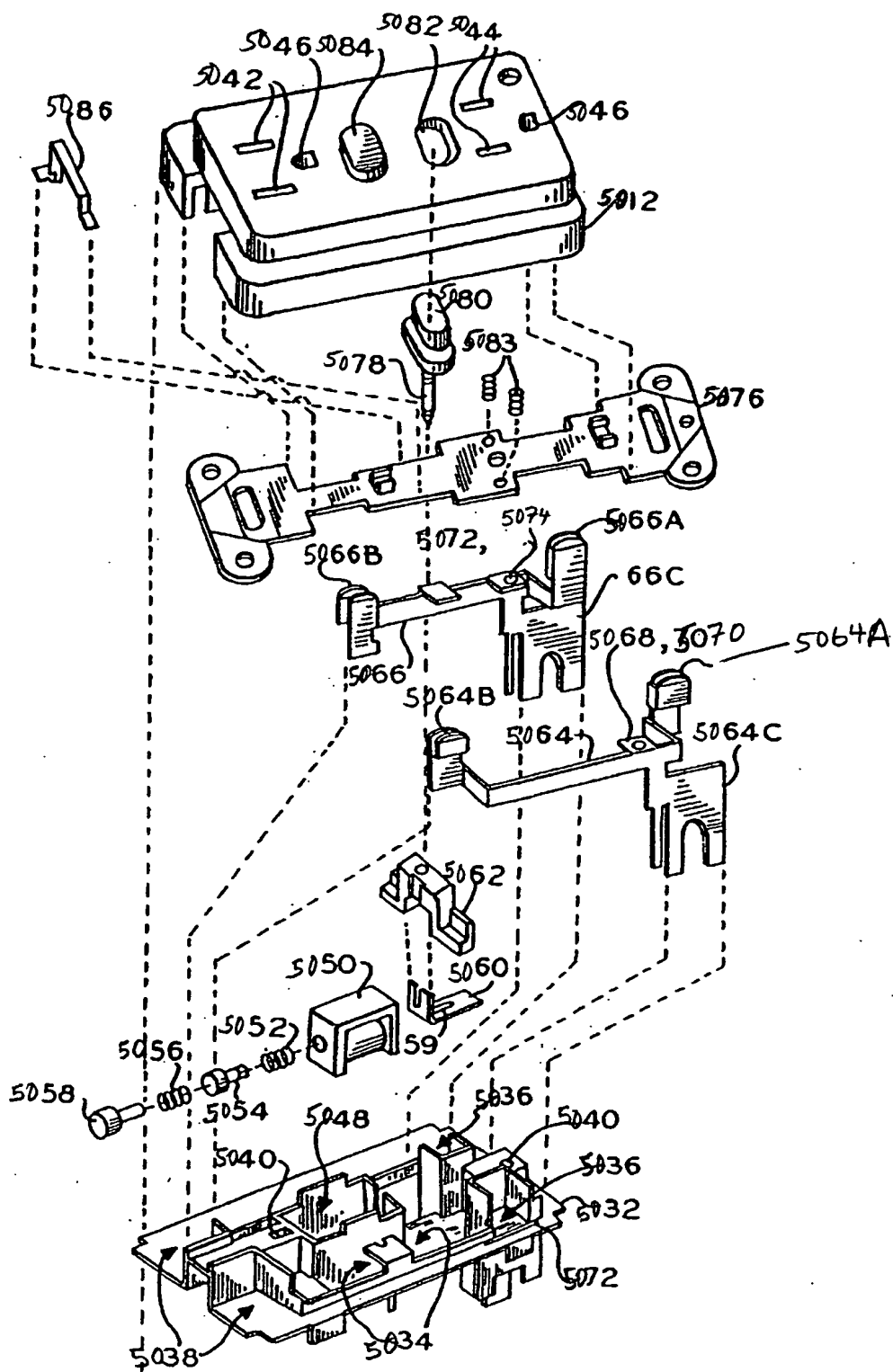


FIG. 102 (PRIOR ART)

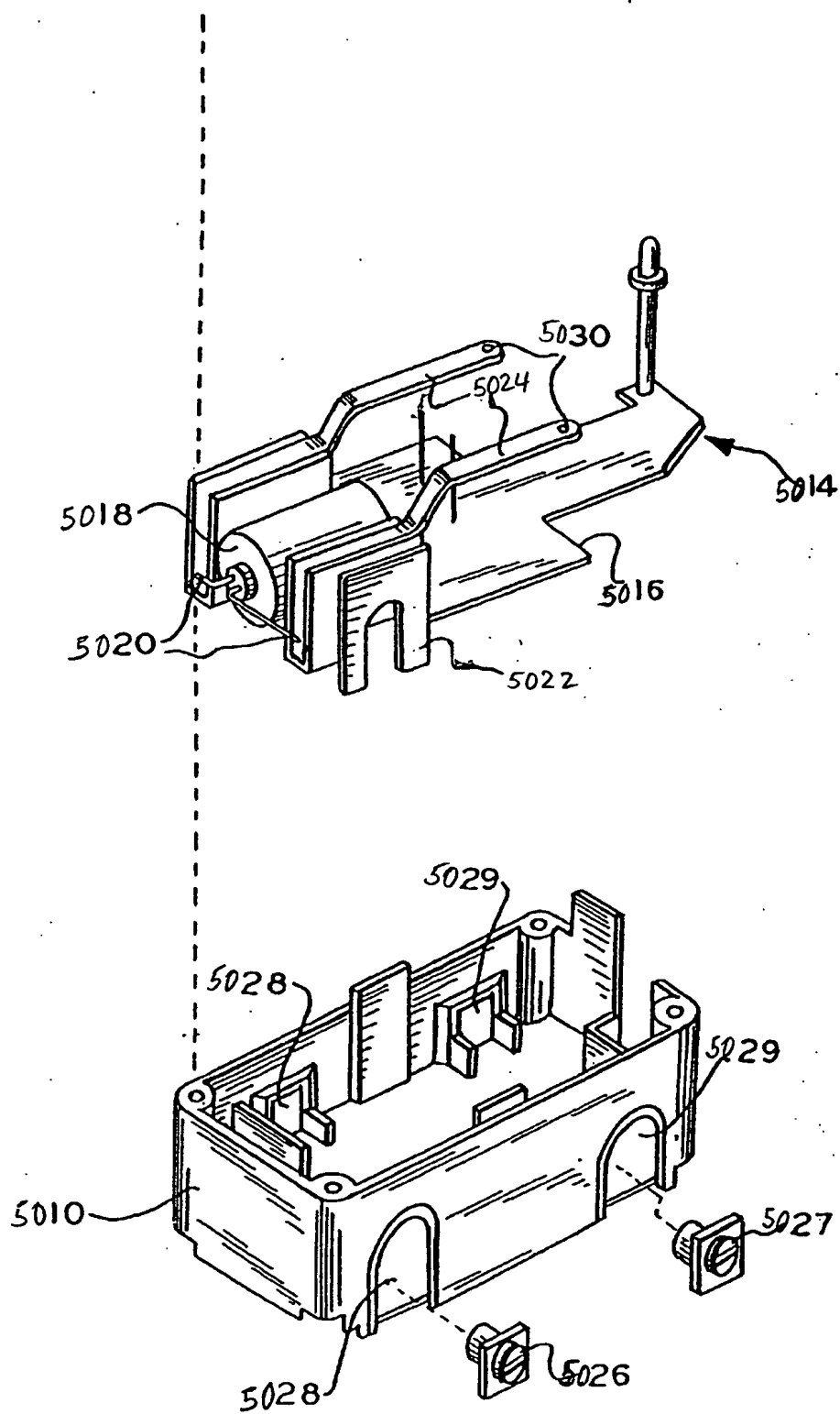


FIG. 103A (PRIOR ART)

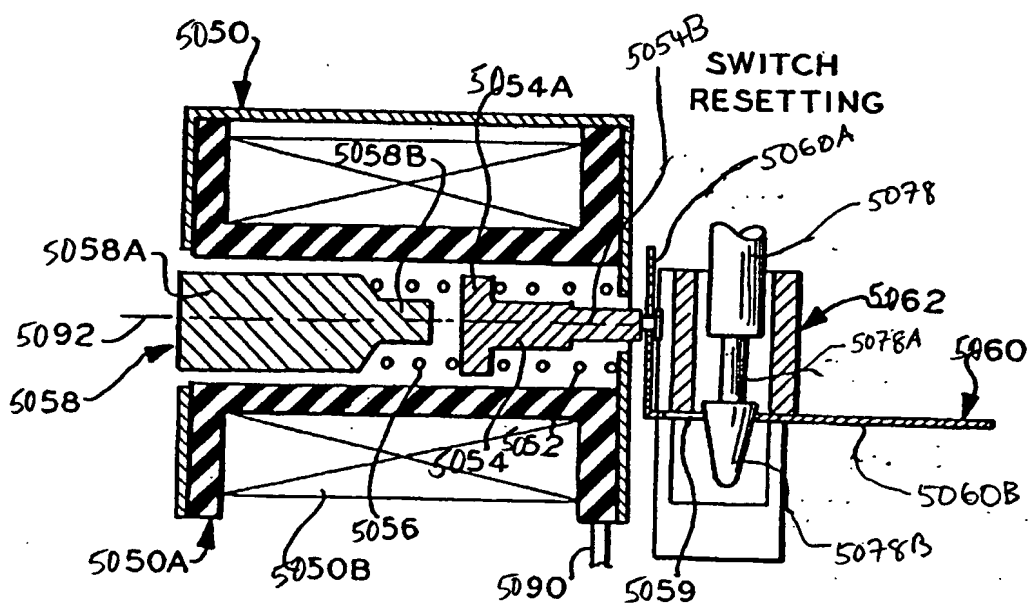
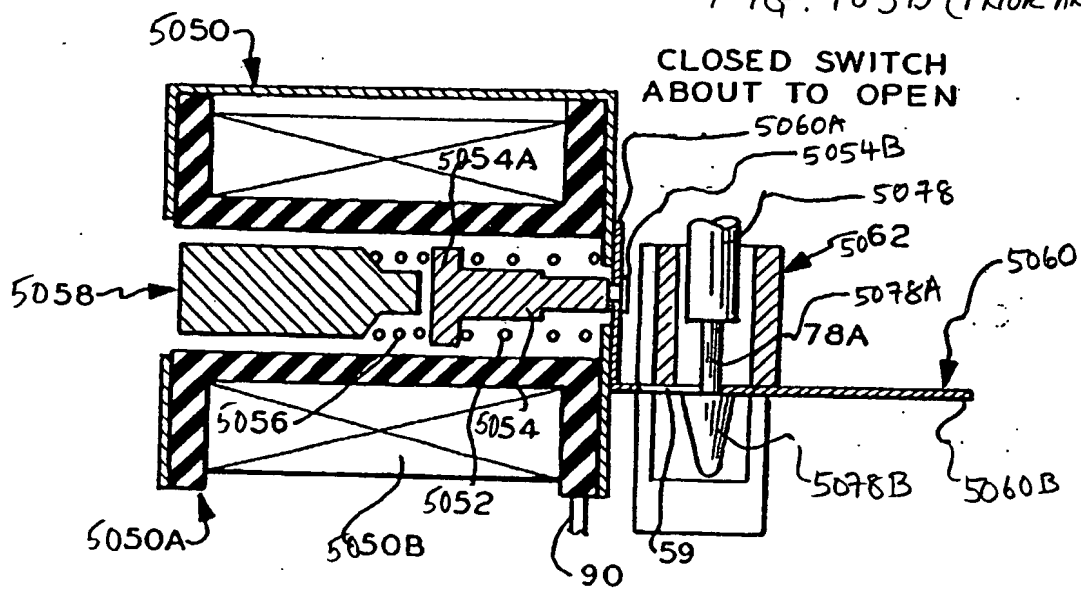


FIG. 103B (PRIOR ART)



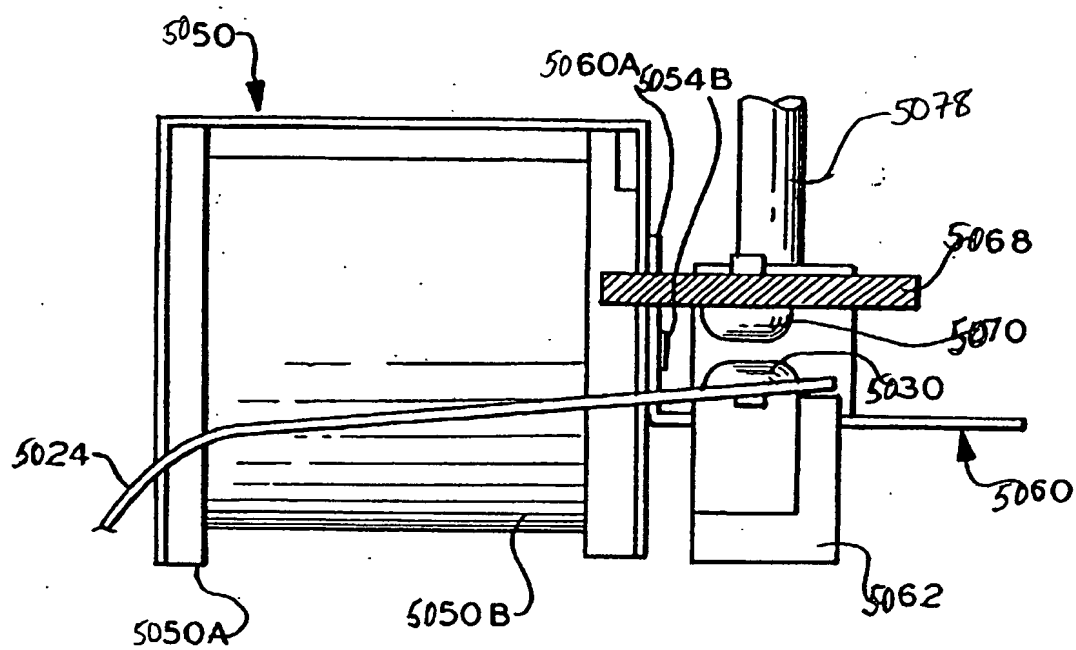


FIG. 105

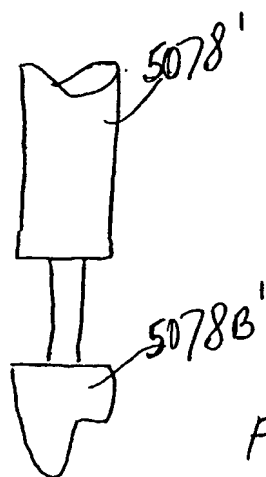
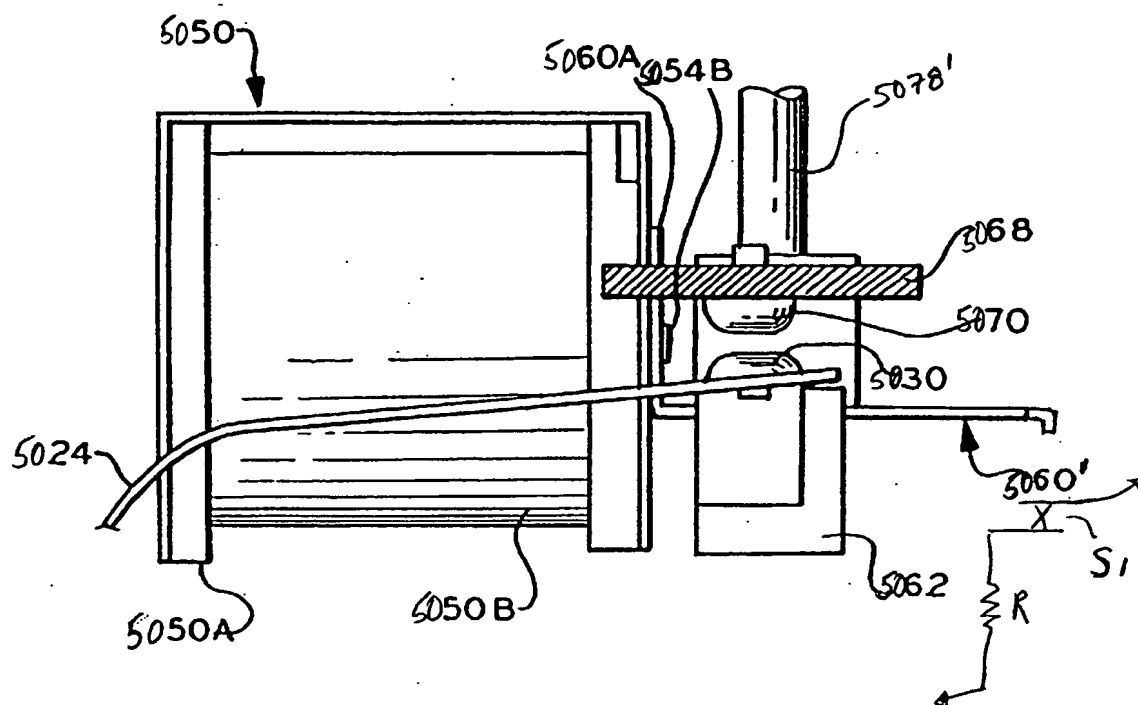


Fig. 106

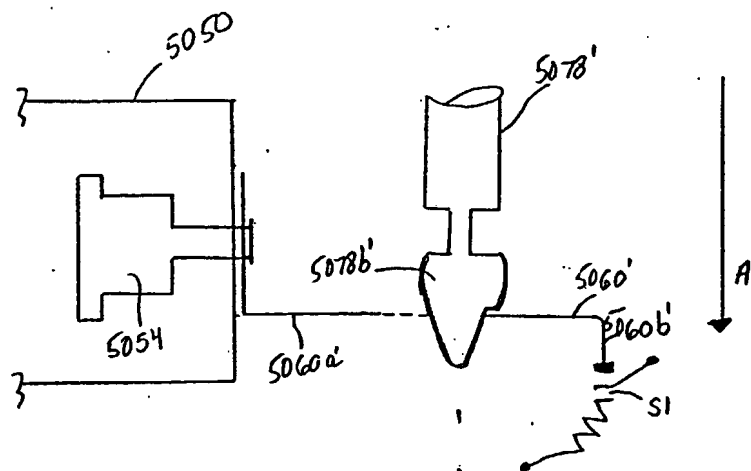


Fig. 107a

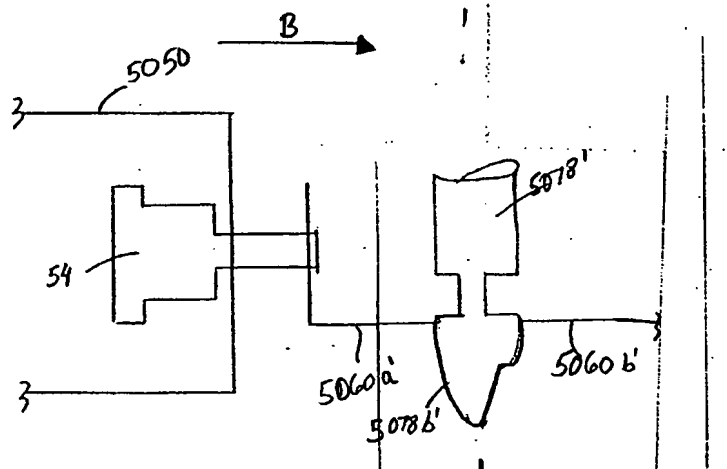


Fig. 107b

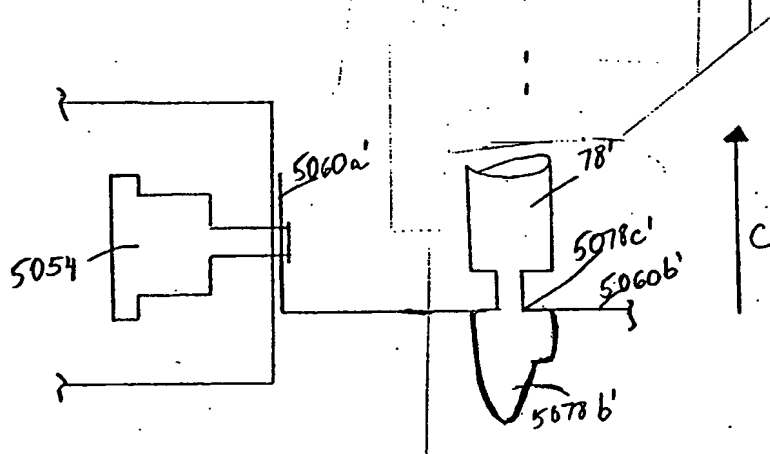


Fig. 107c

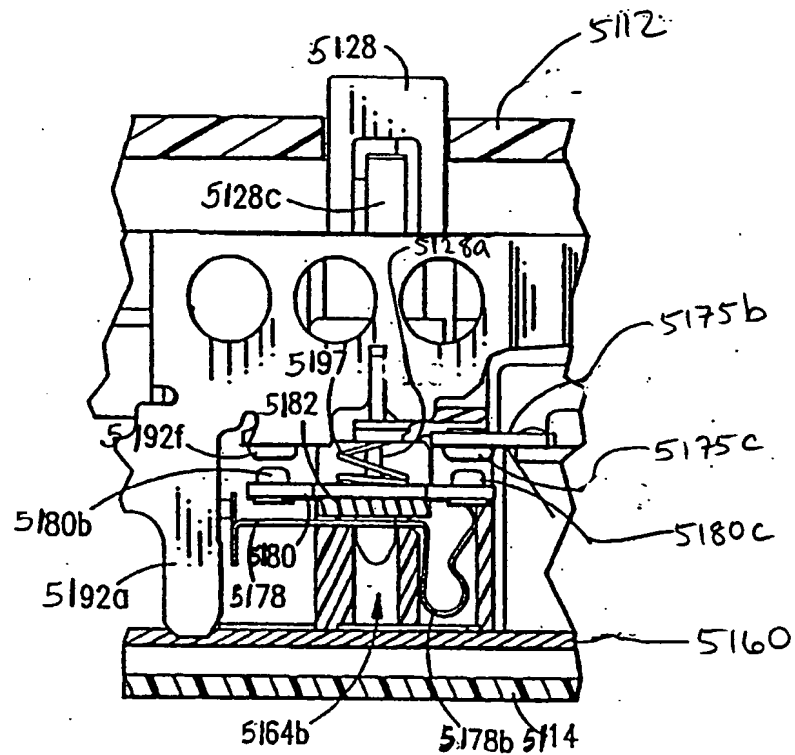


FIG. 108a

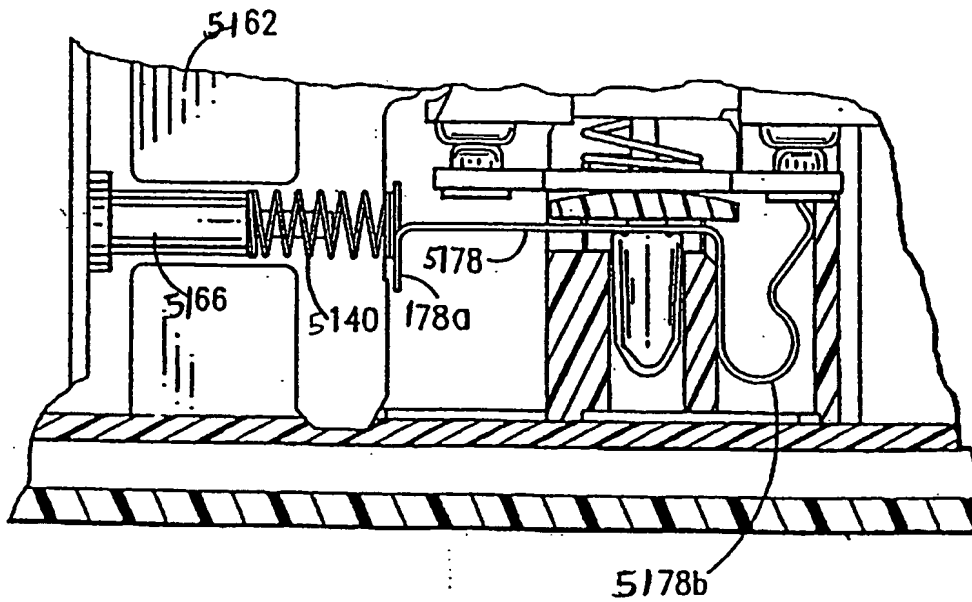


FIG. 108b

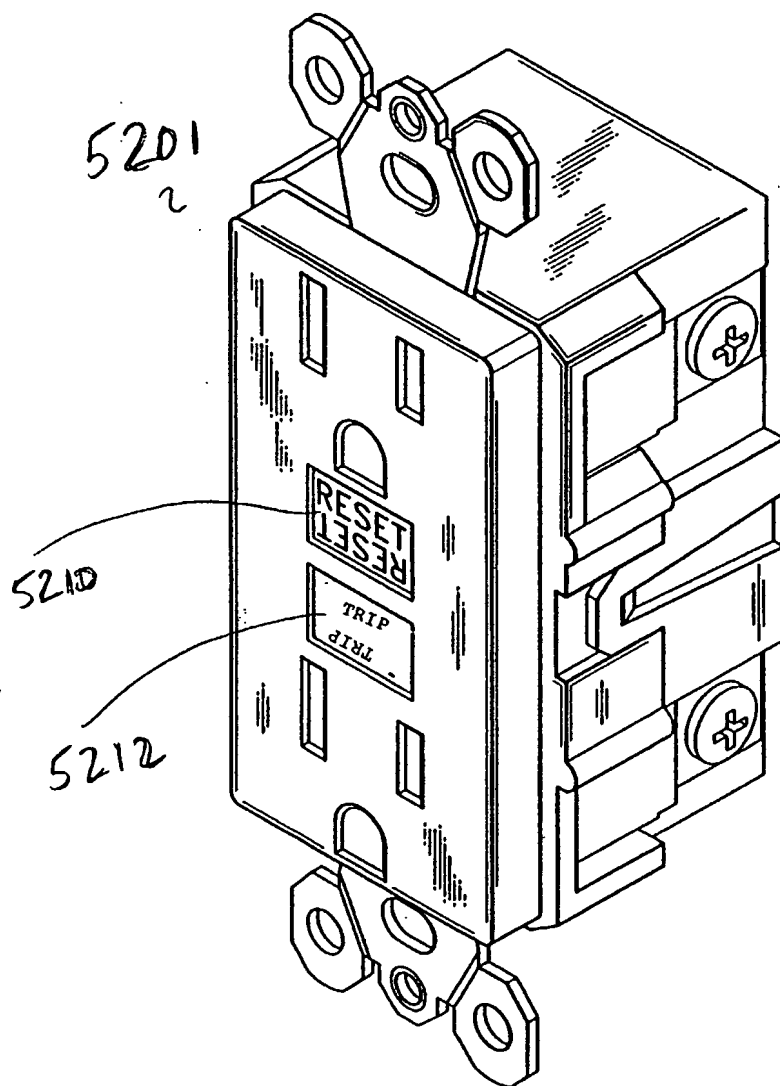


FIG. 109

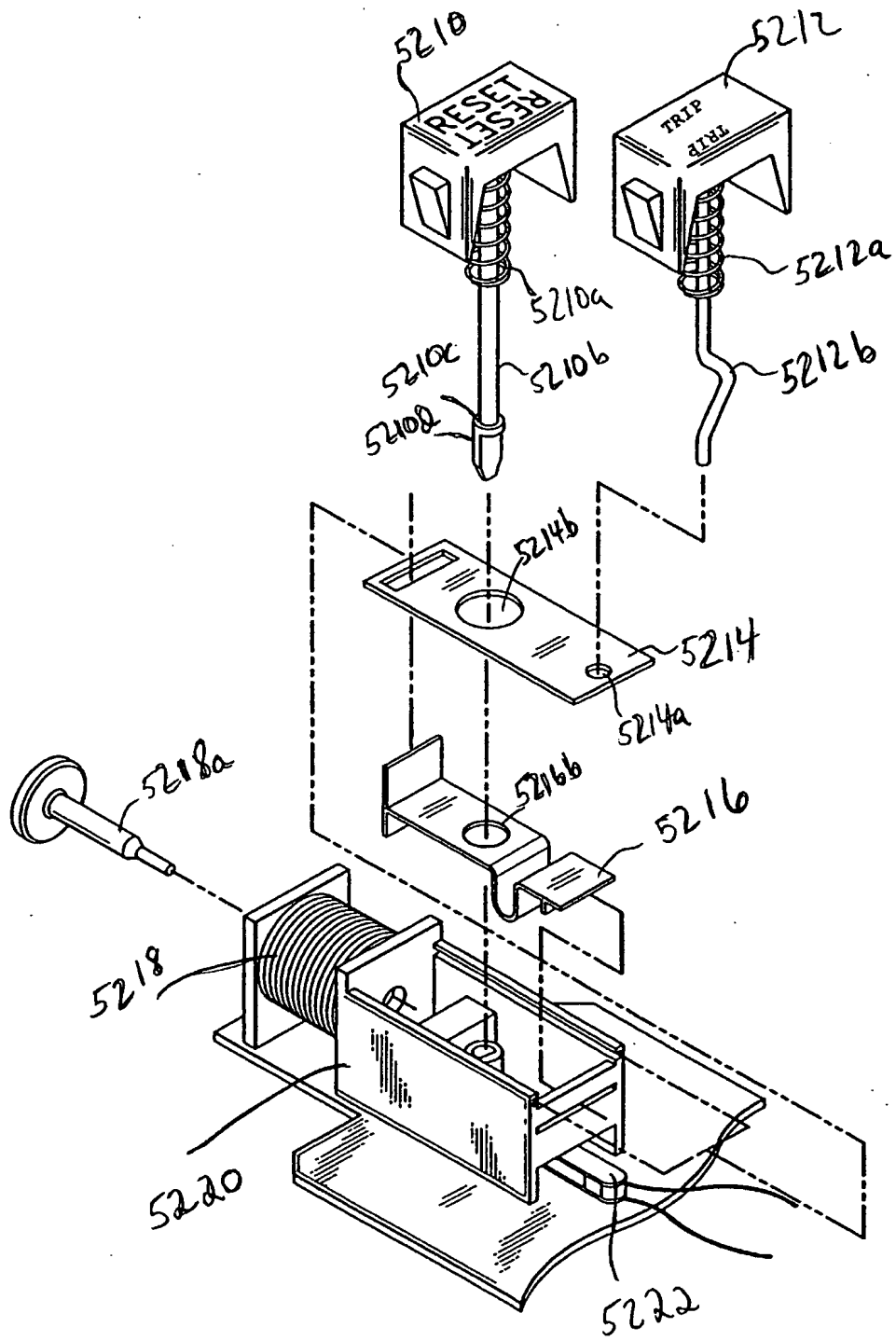
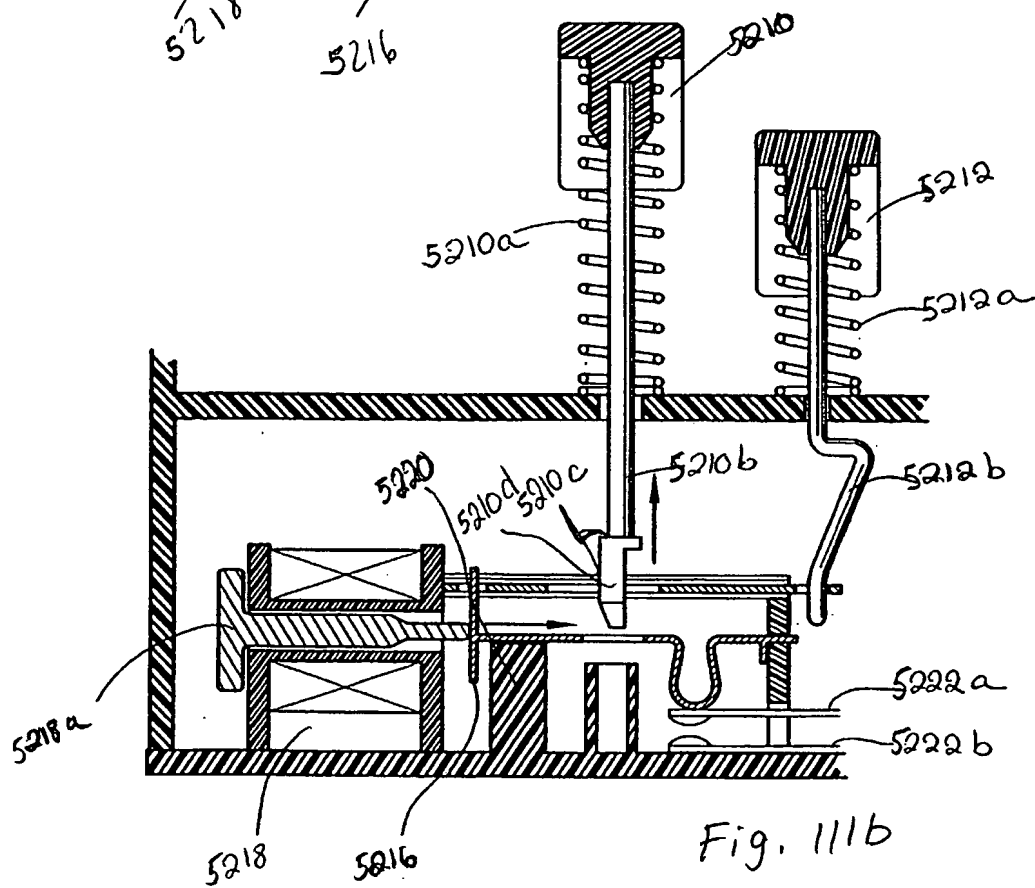
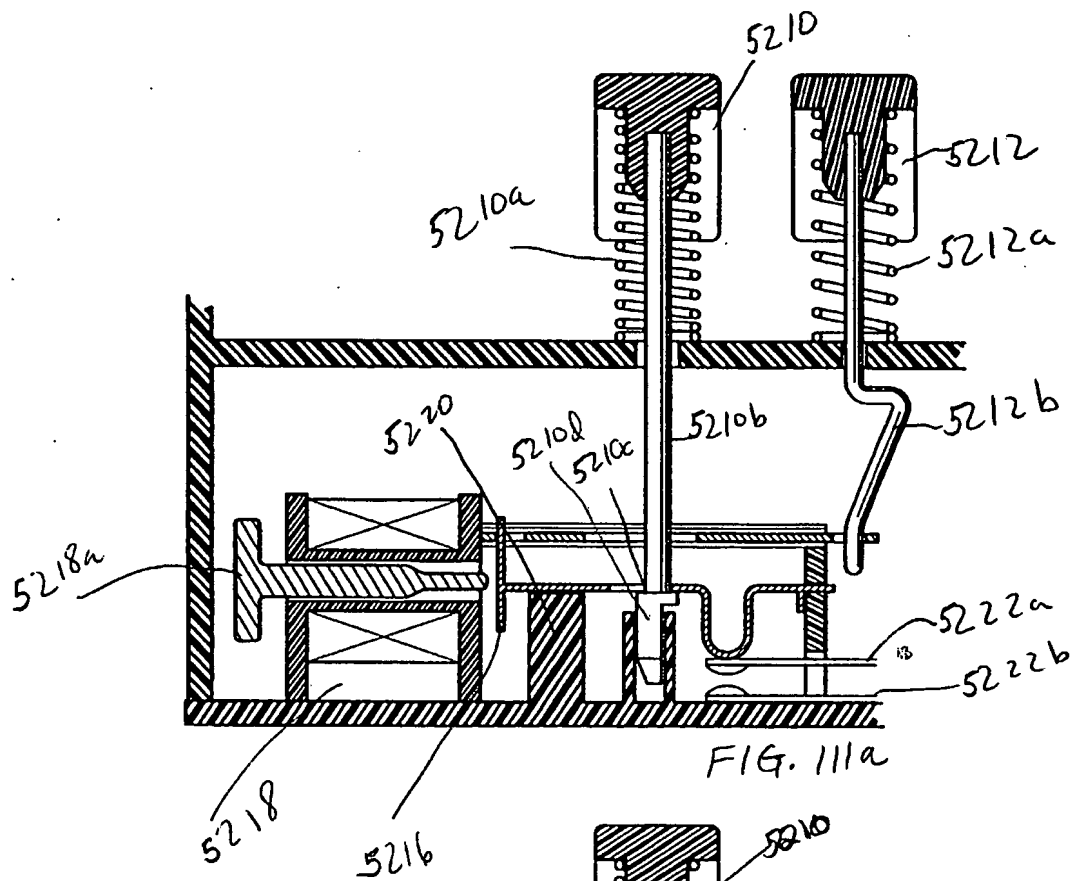
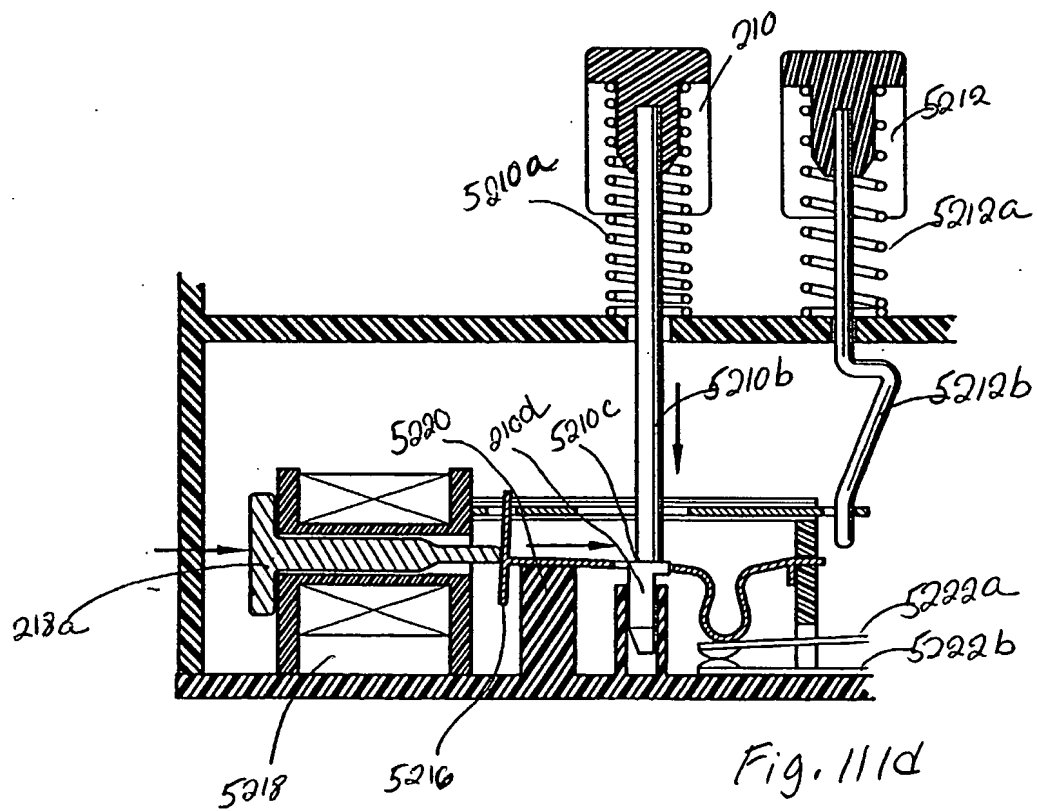
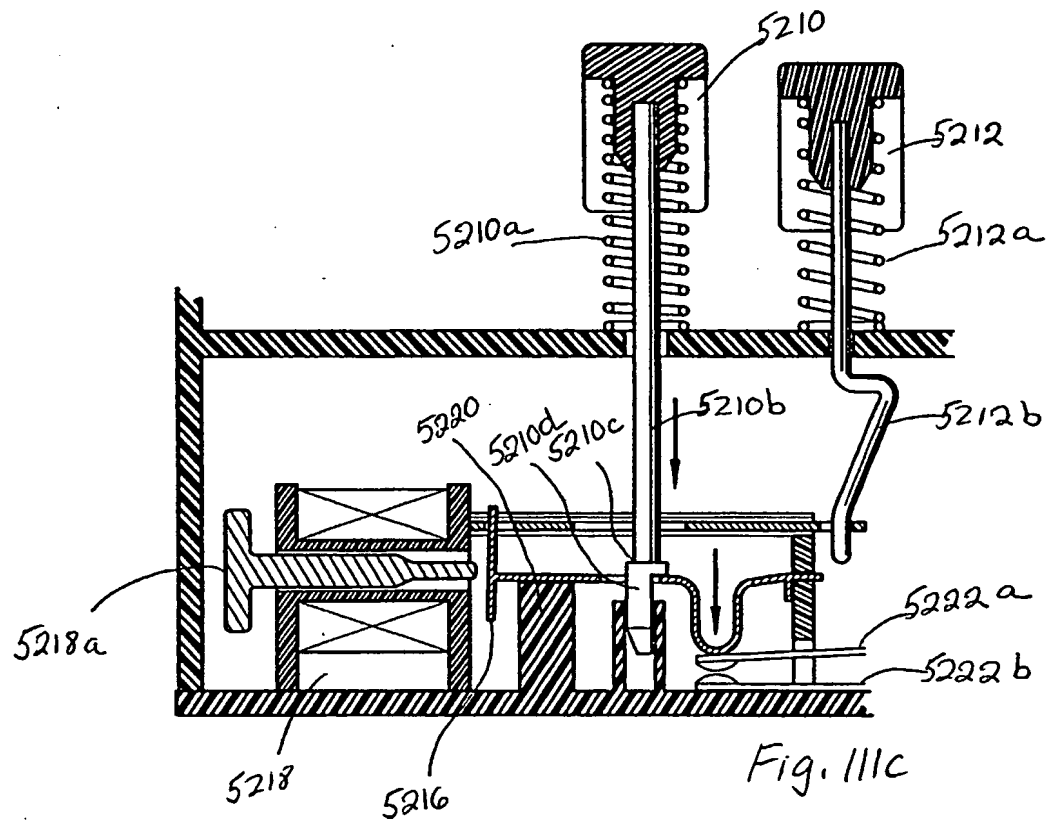
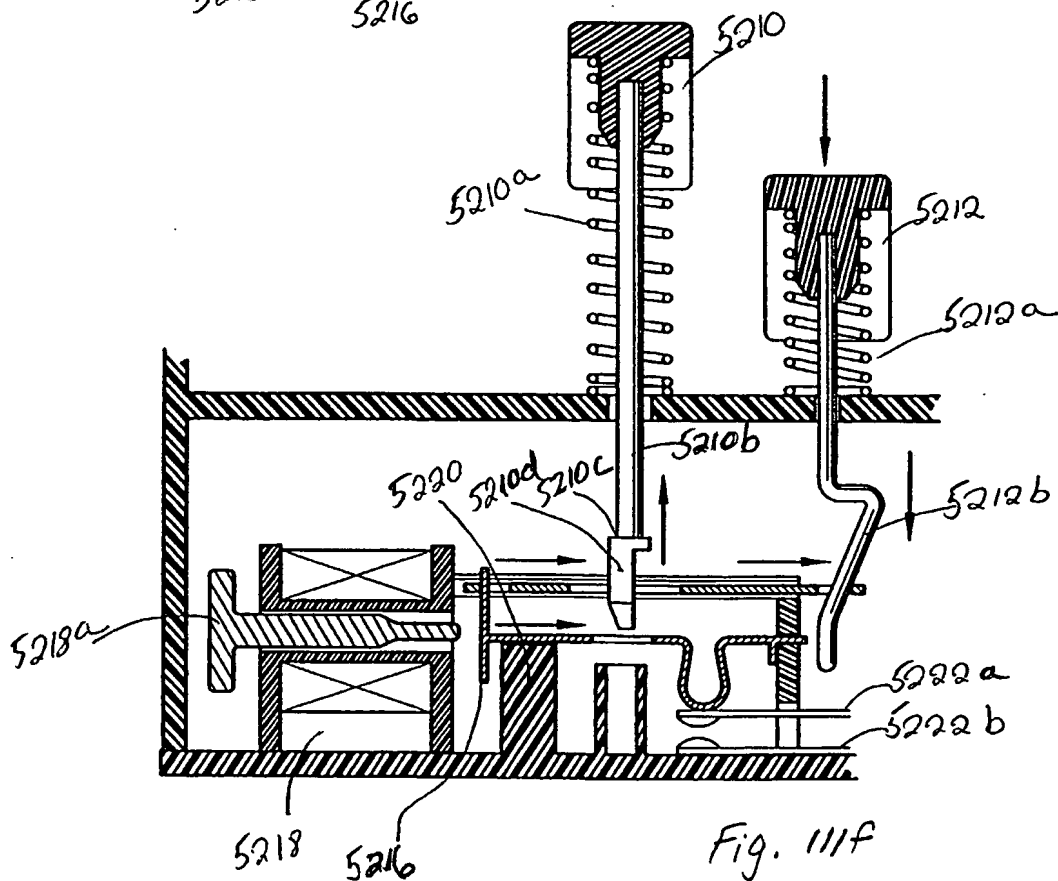
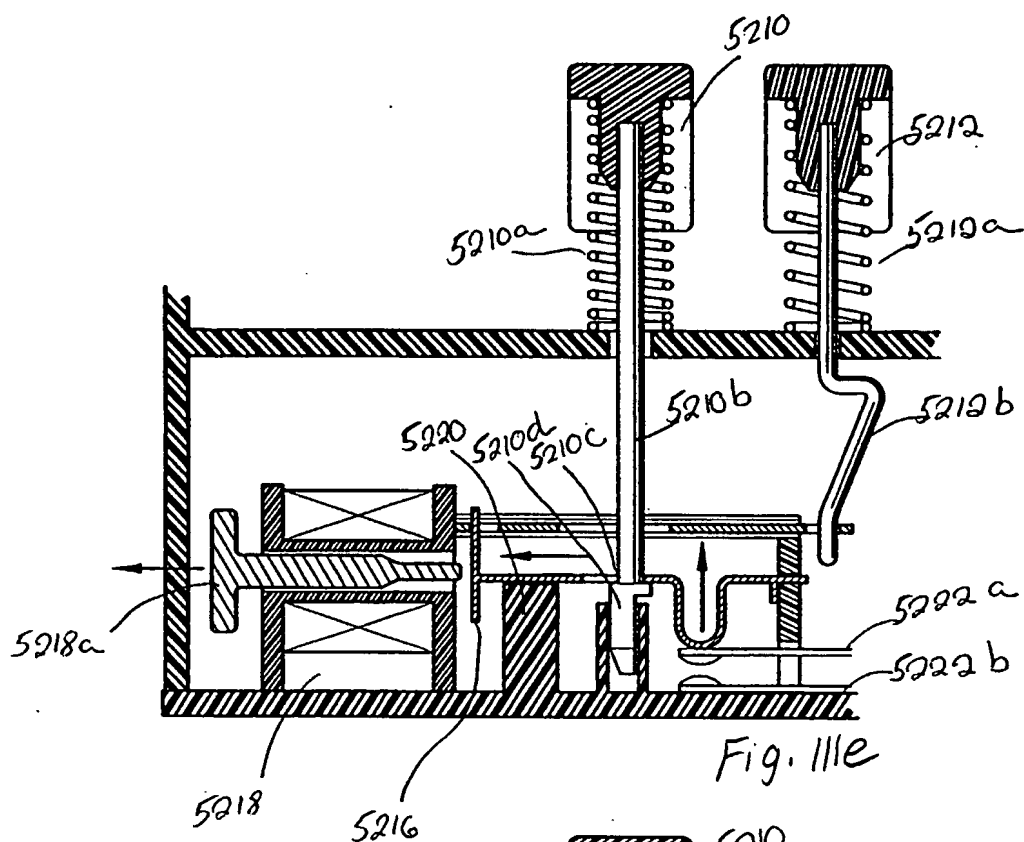


FIG. 110







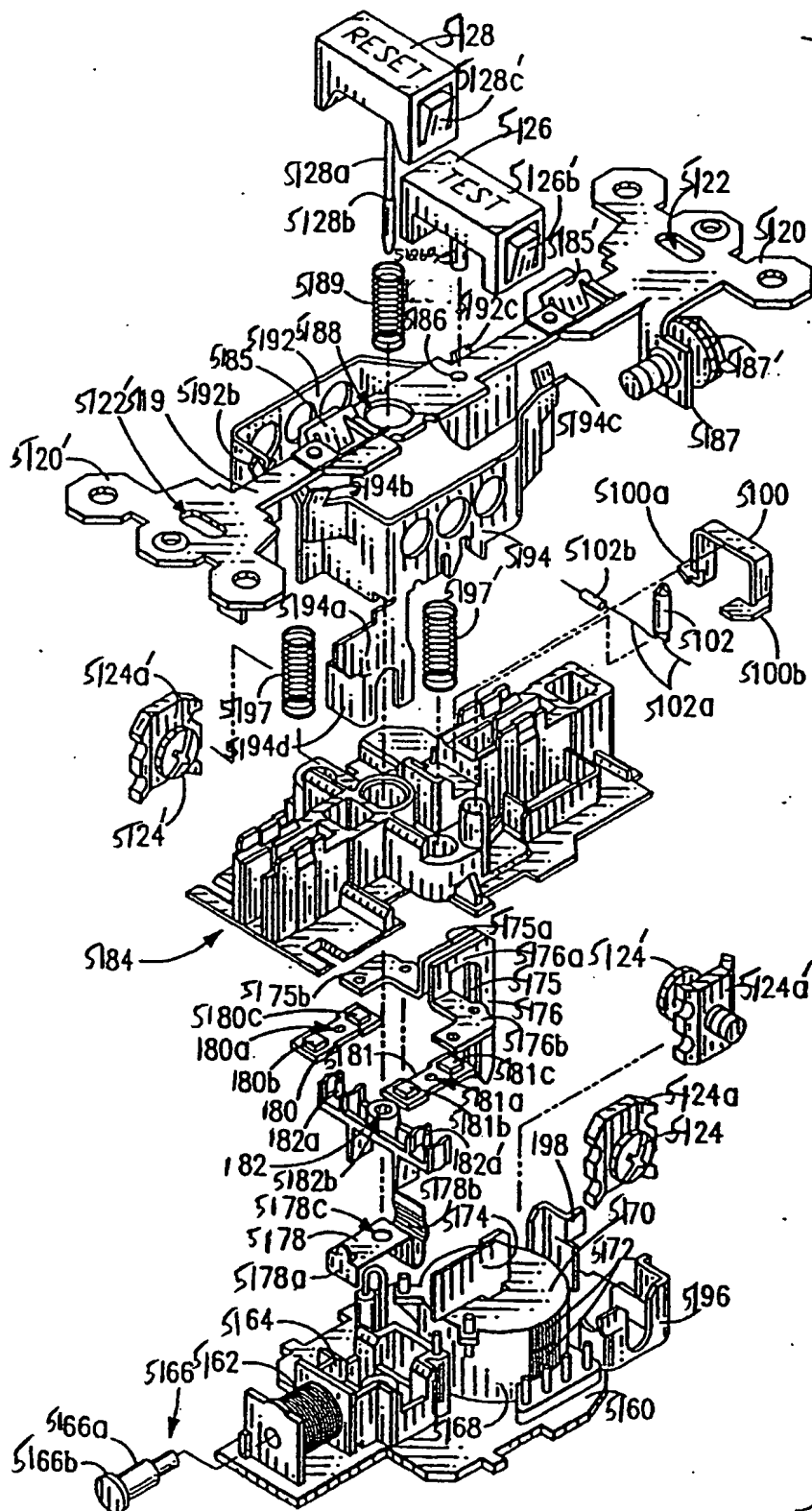


FIG. 112

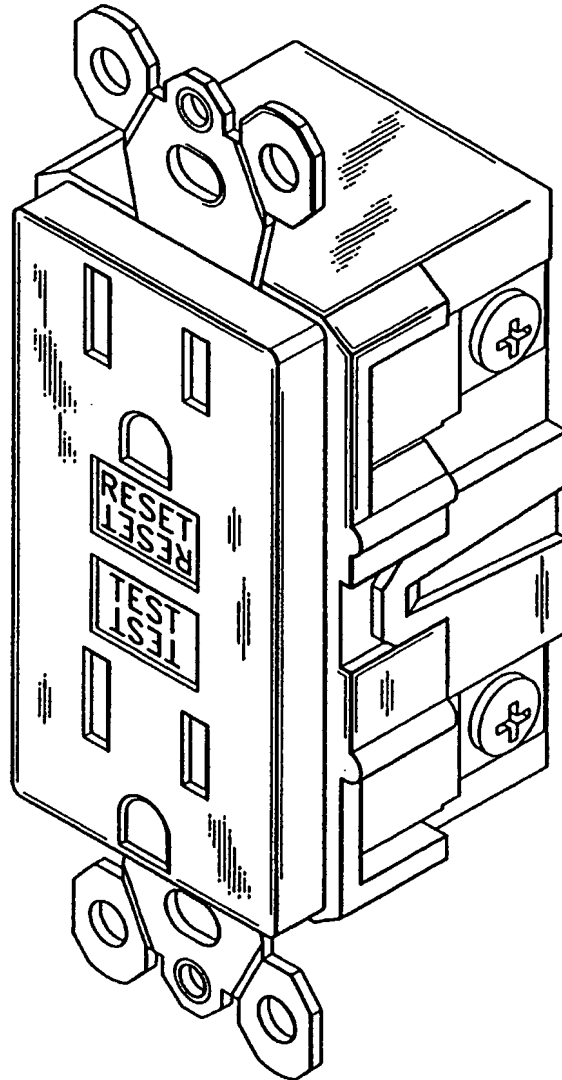
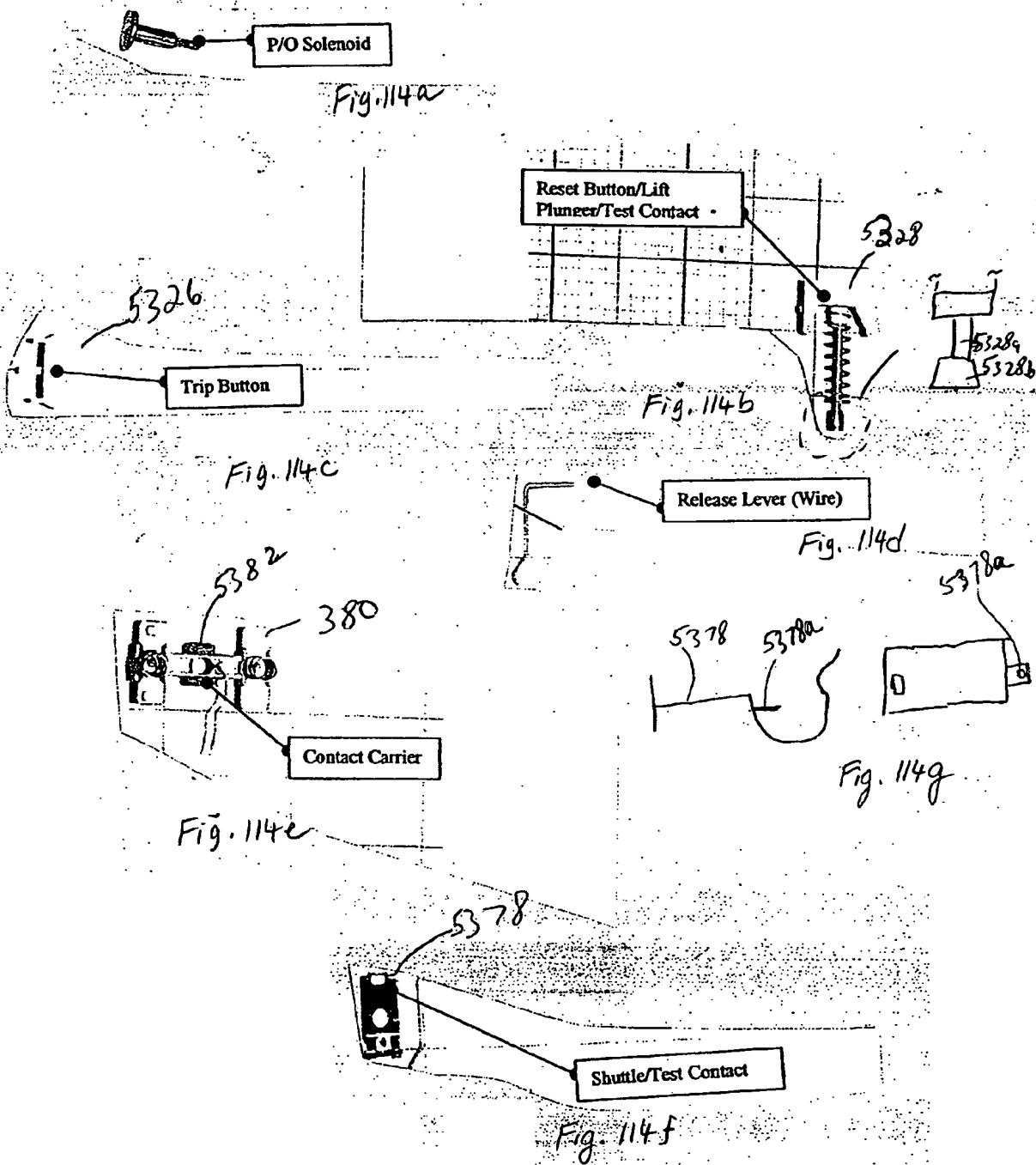
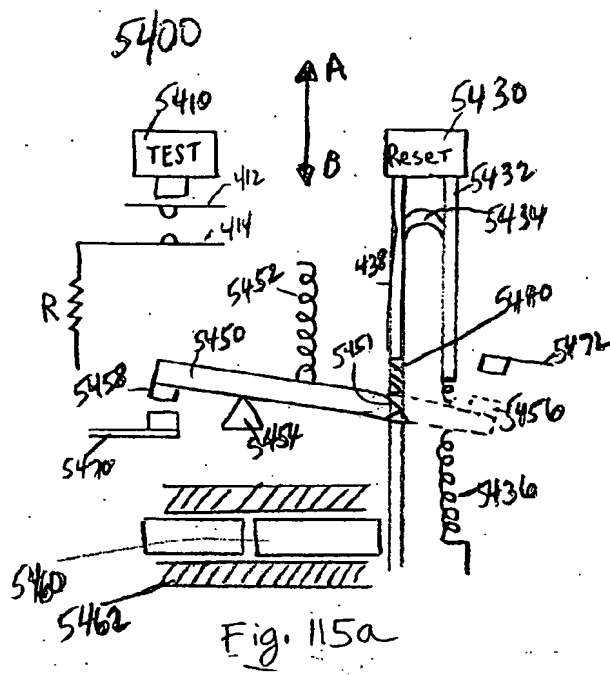
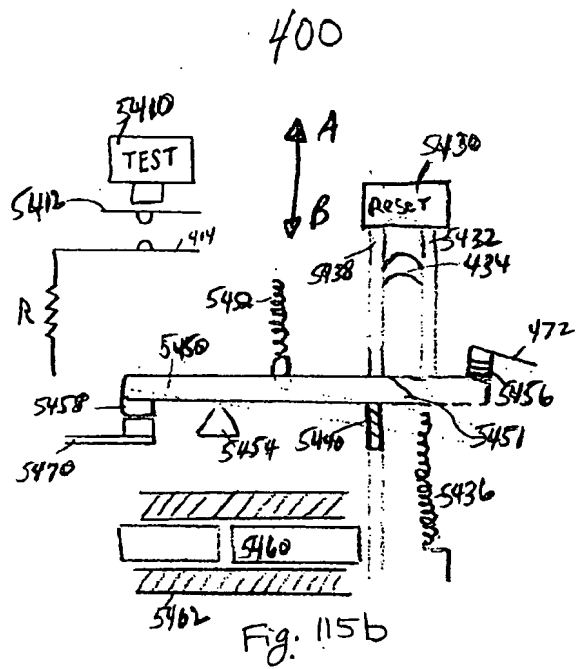


FIG. 113

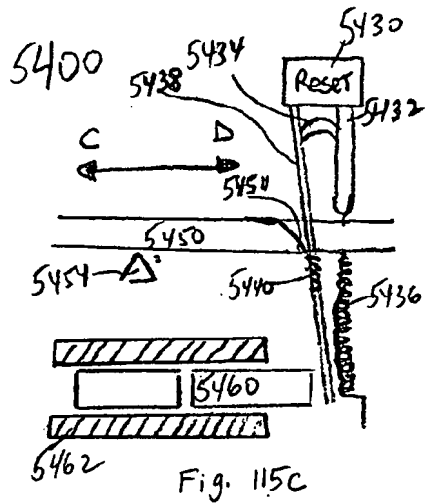




(PRIOR ART)



(PRIOR ART)



(PRIOR ART)

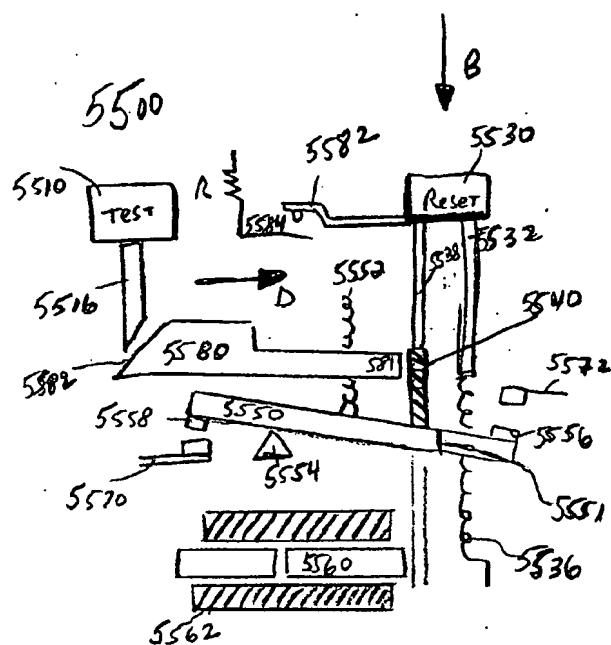
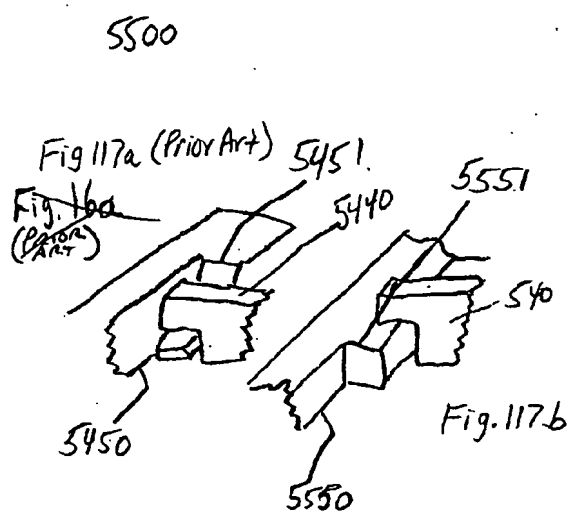


Fig. 116



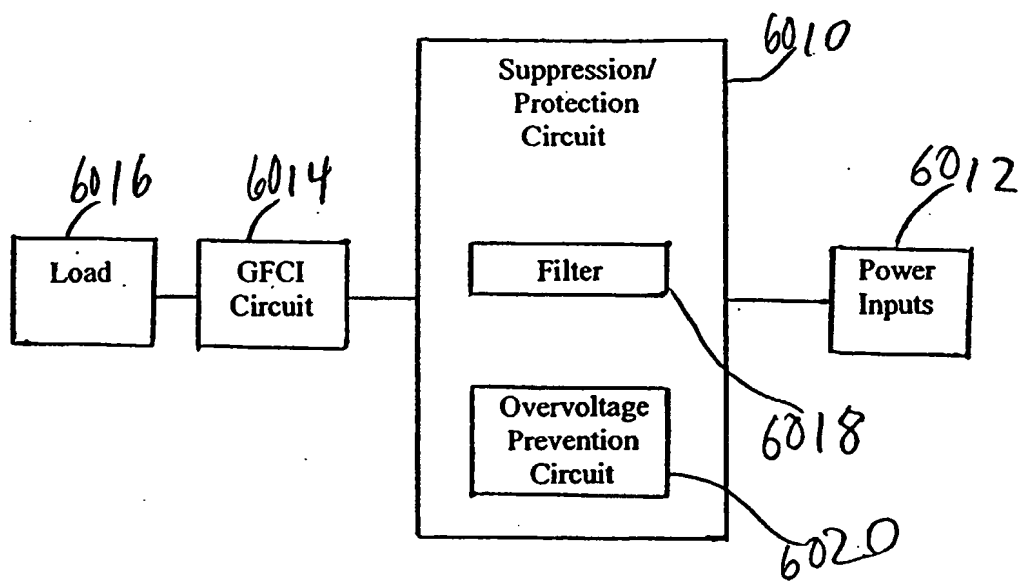


FIG. 118

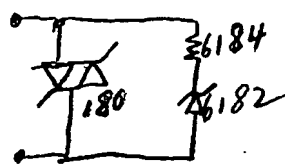


Fig. 124a

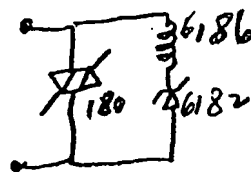


Fig. 124b

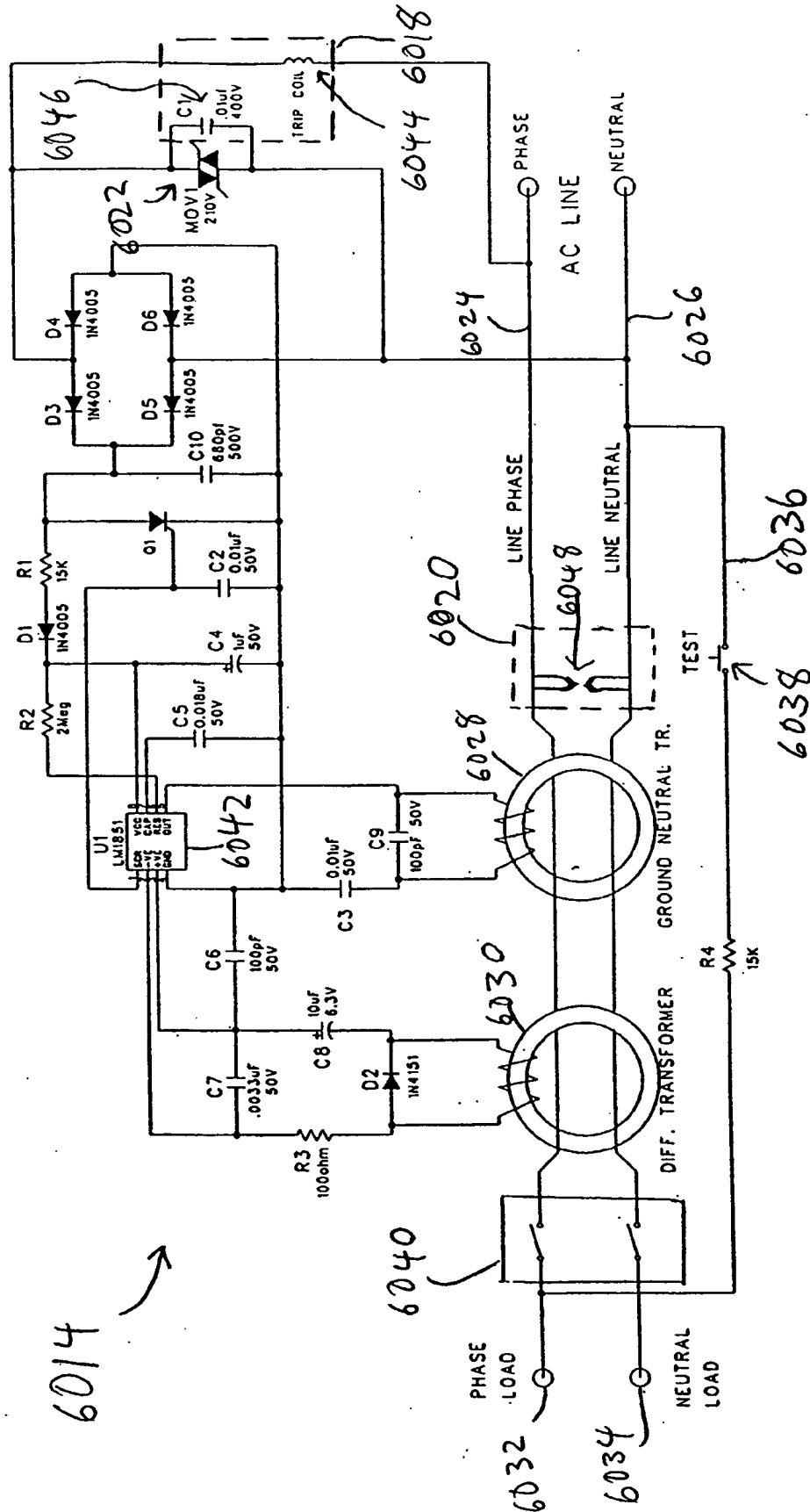


Fig. 119

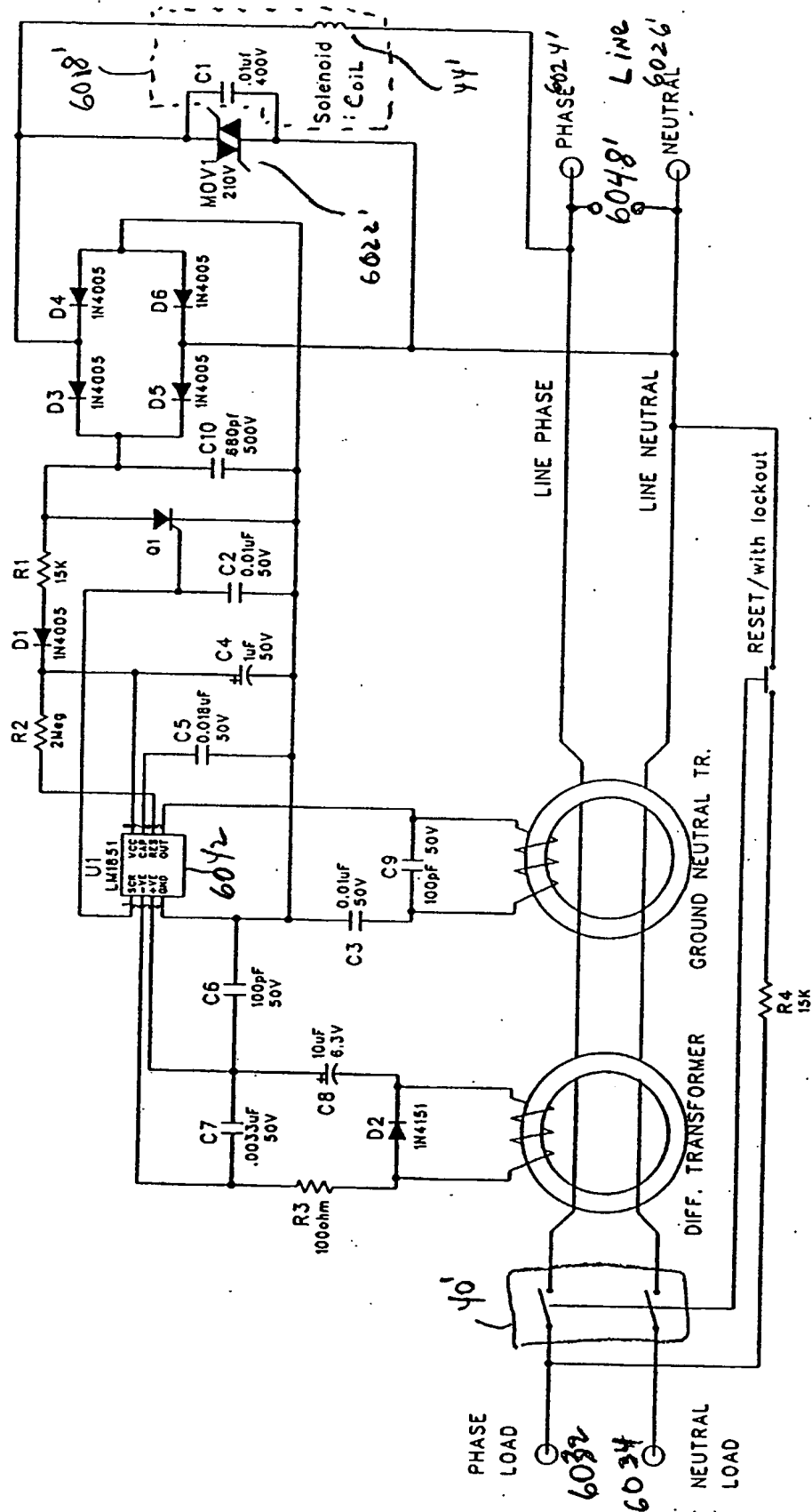


Fig. 120

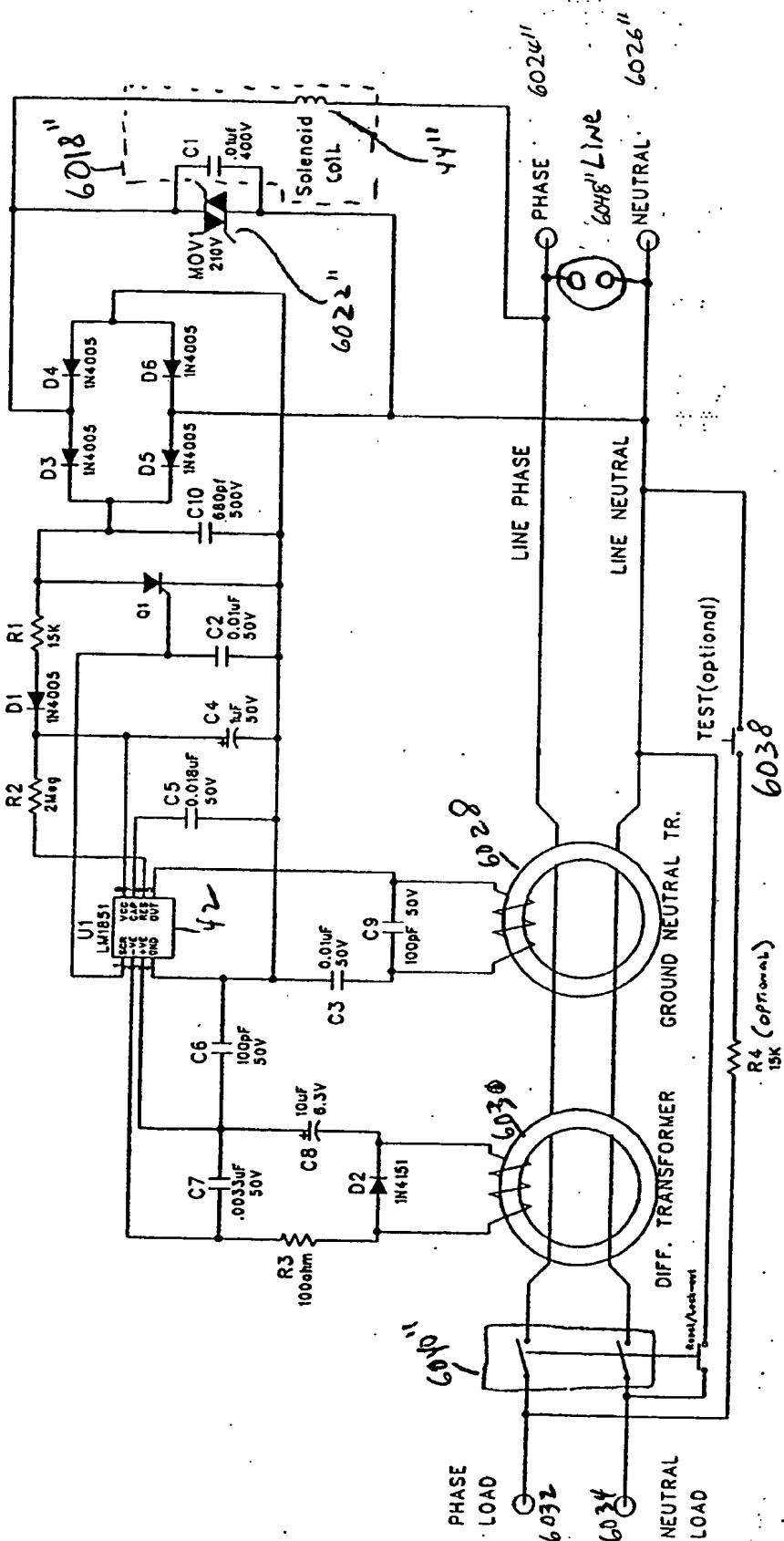


Fig. 121

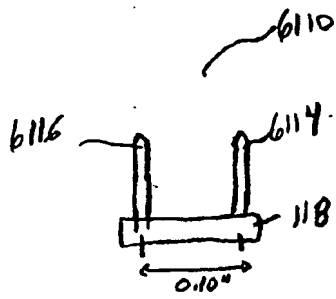


Fig. 122a

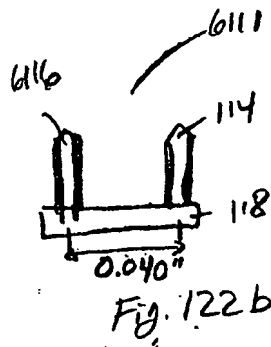


Fig. 122b

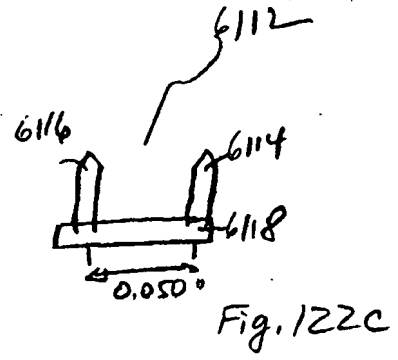


Fig. 122c

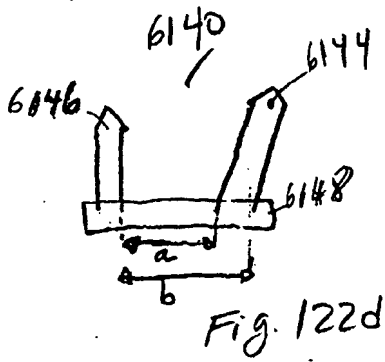


Fig. 122d

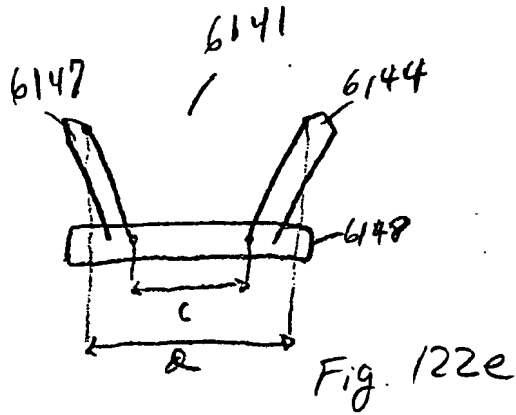


Fig. 122e

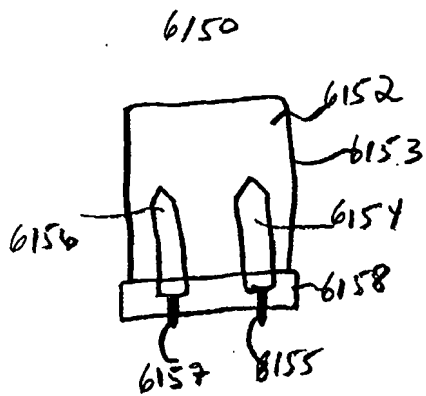


Fig. 123a

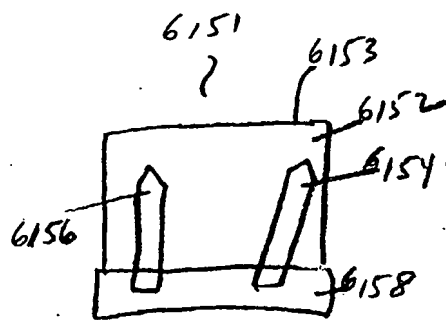


Fig. 123b

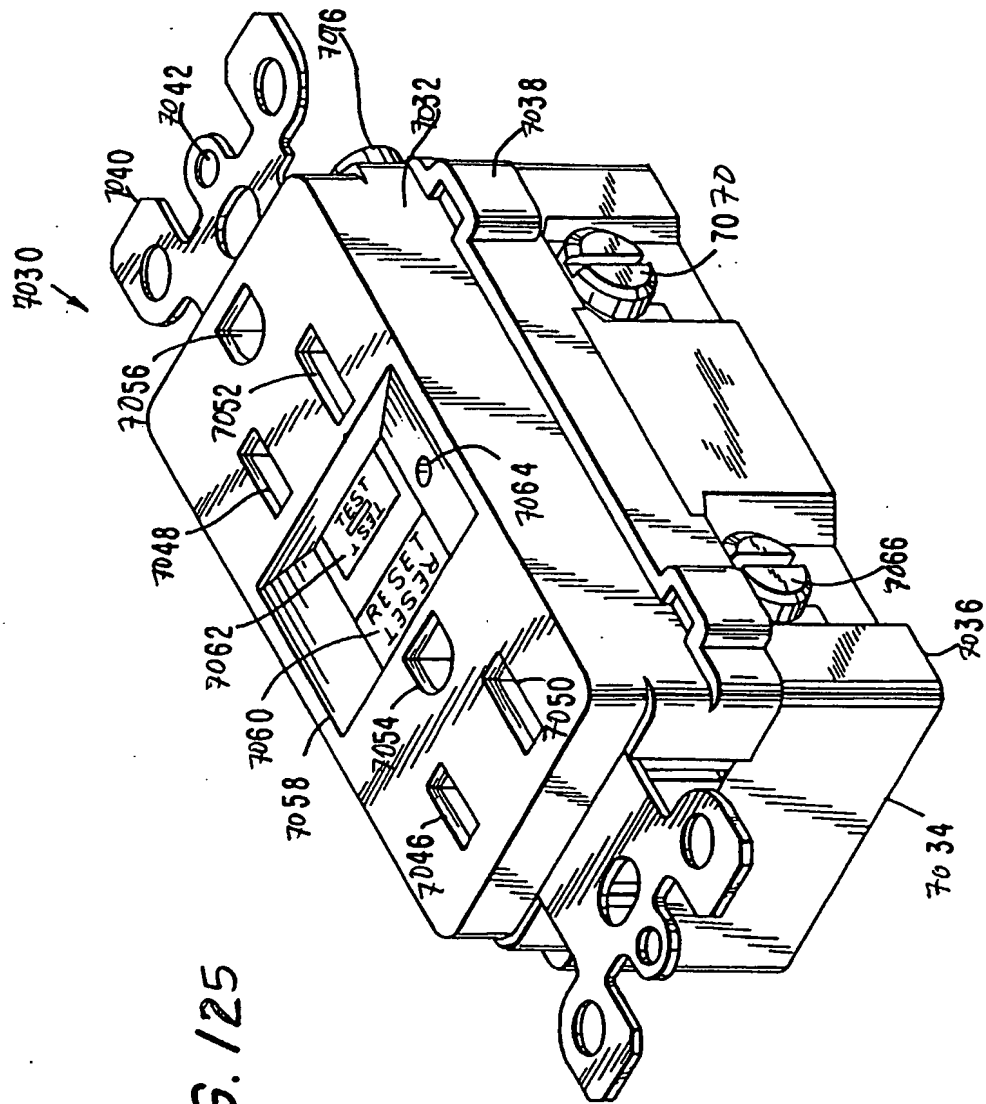


FIG. 125

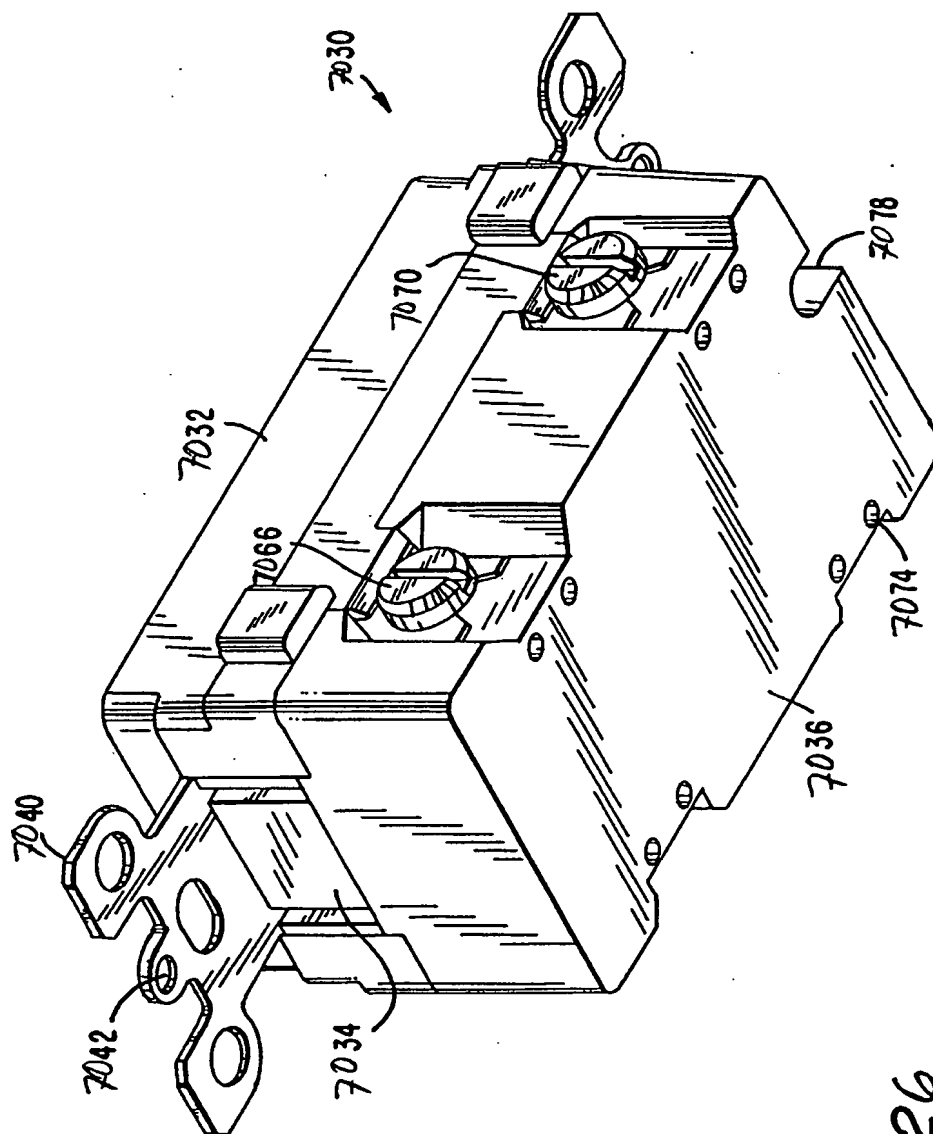


FIG. 126

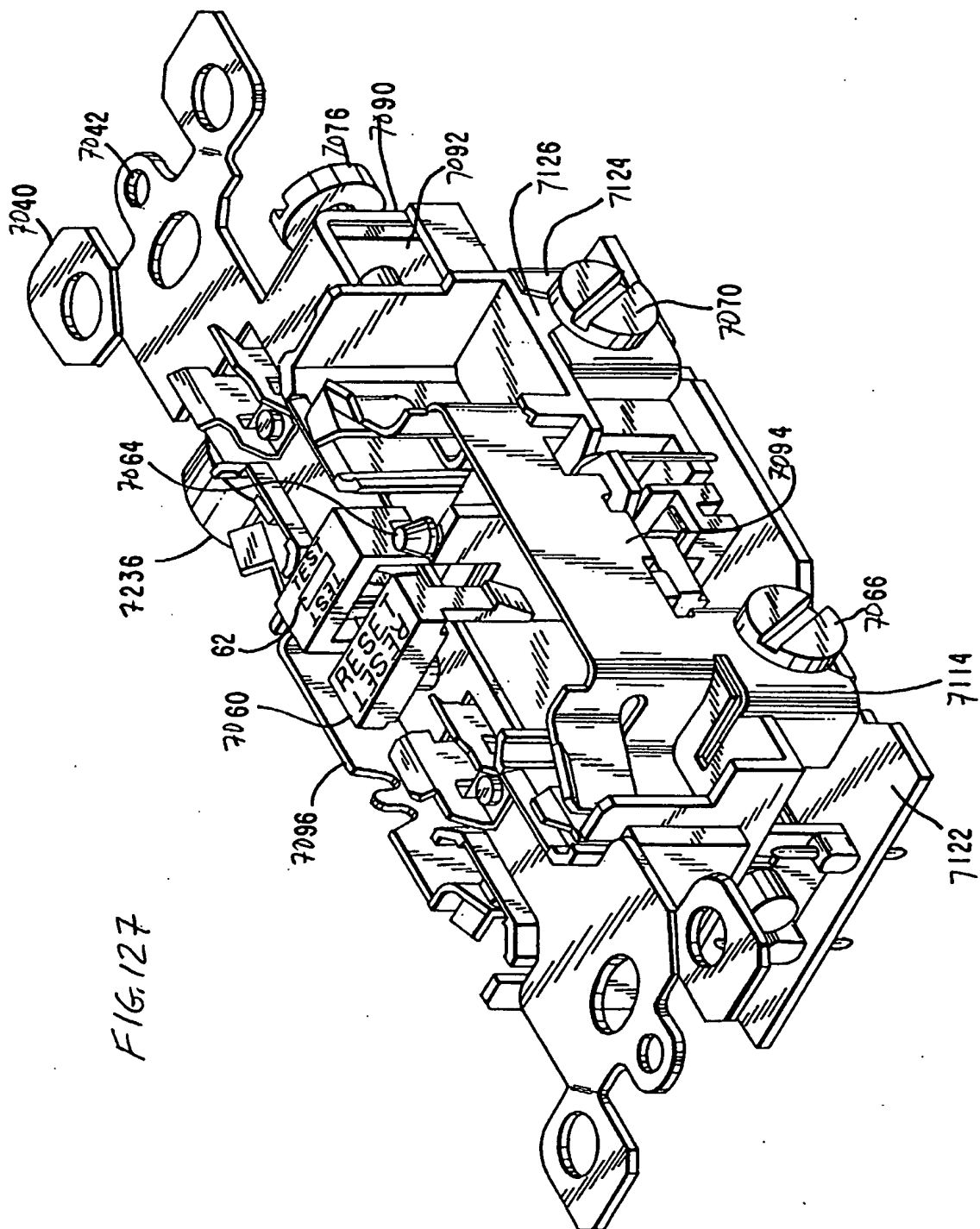
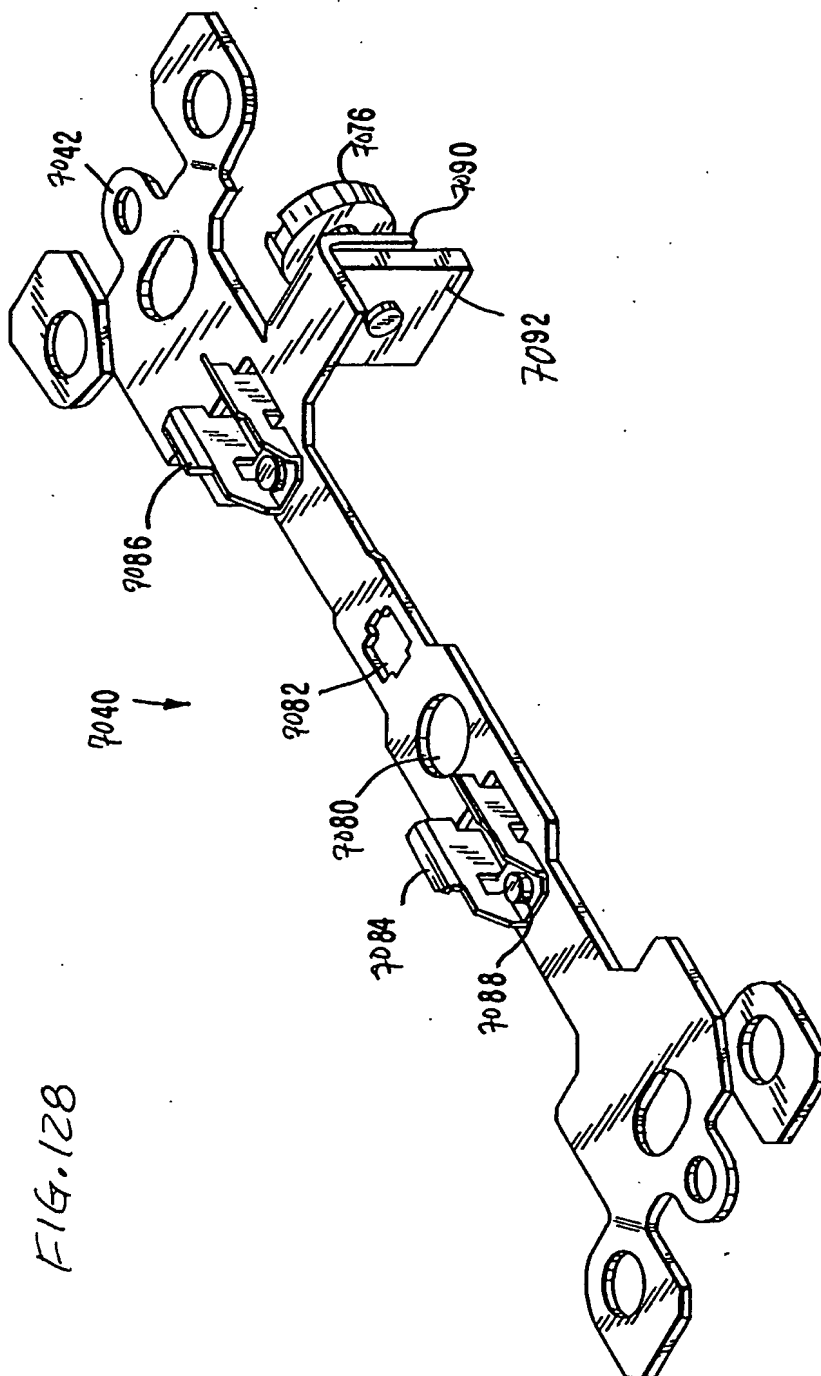


FIG. 127



821.513

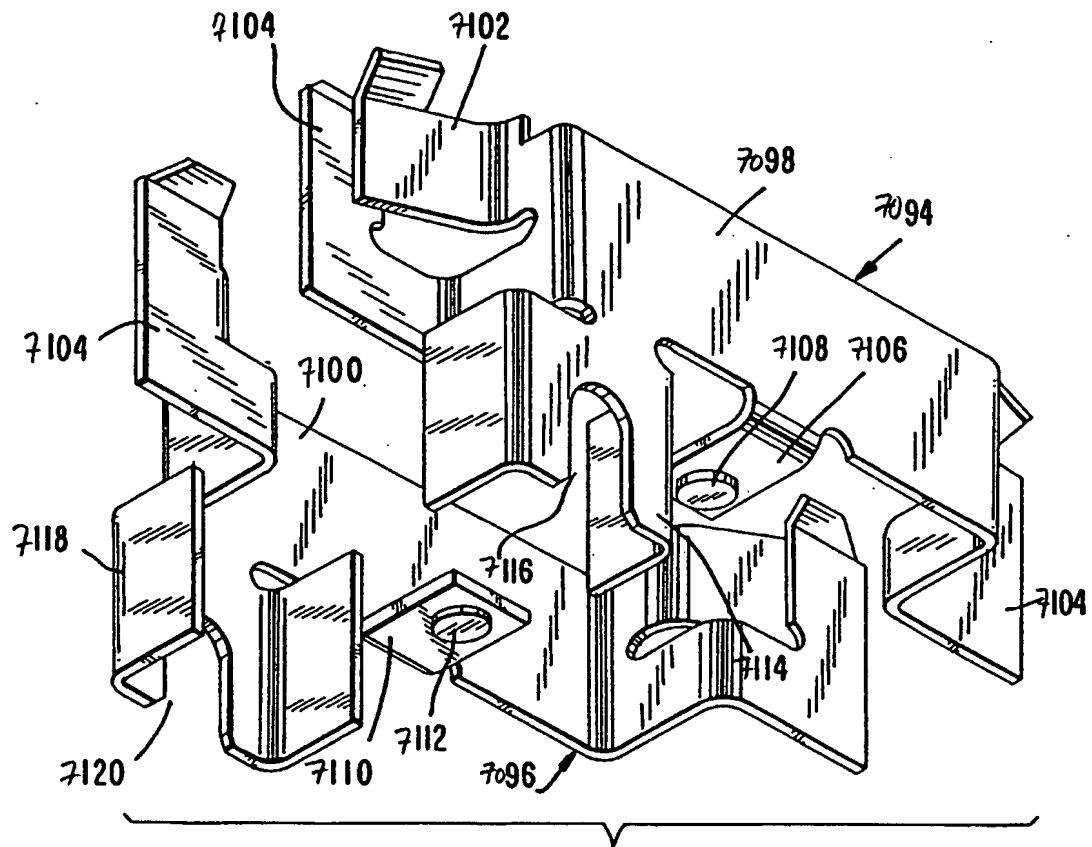
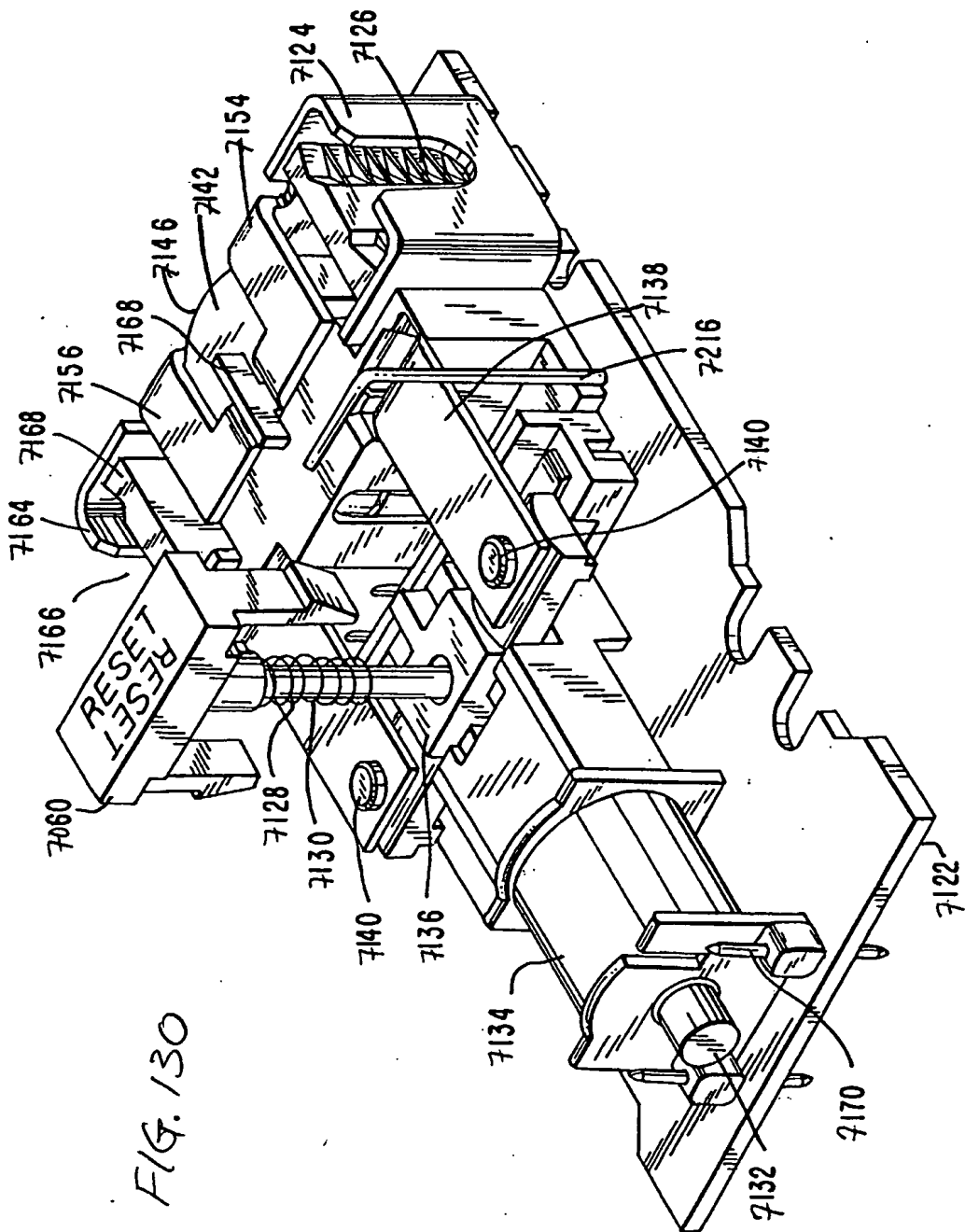
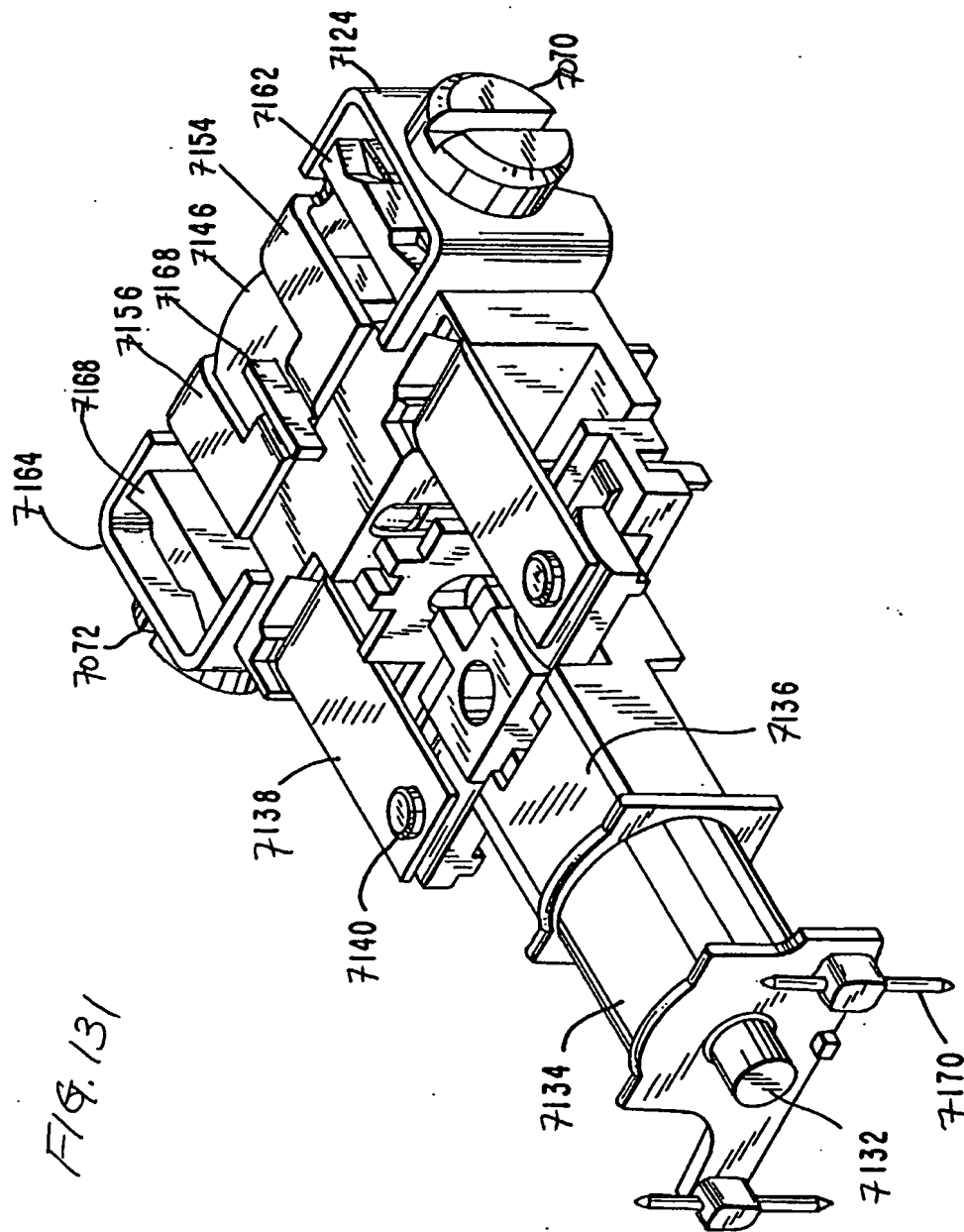
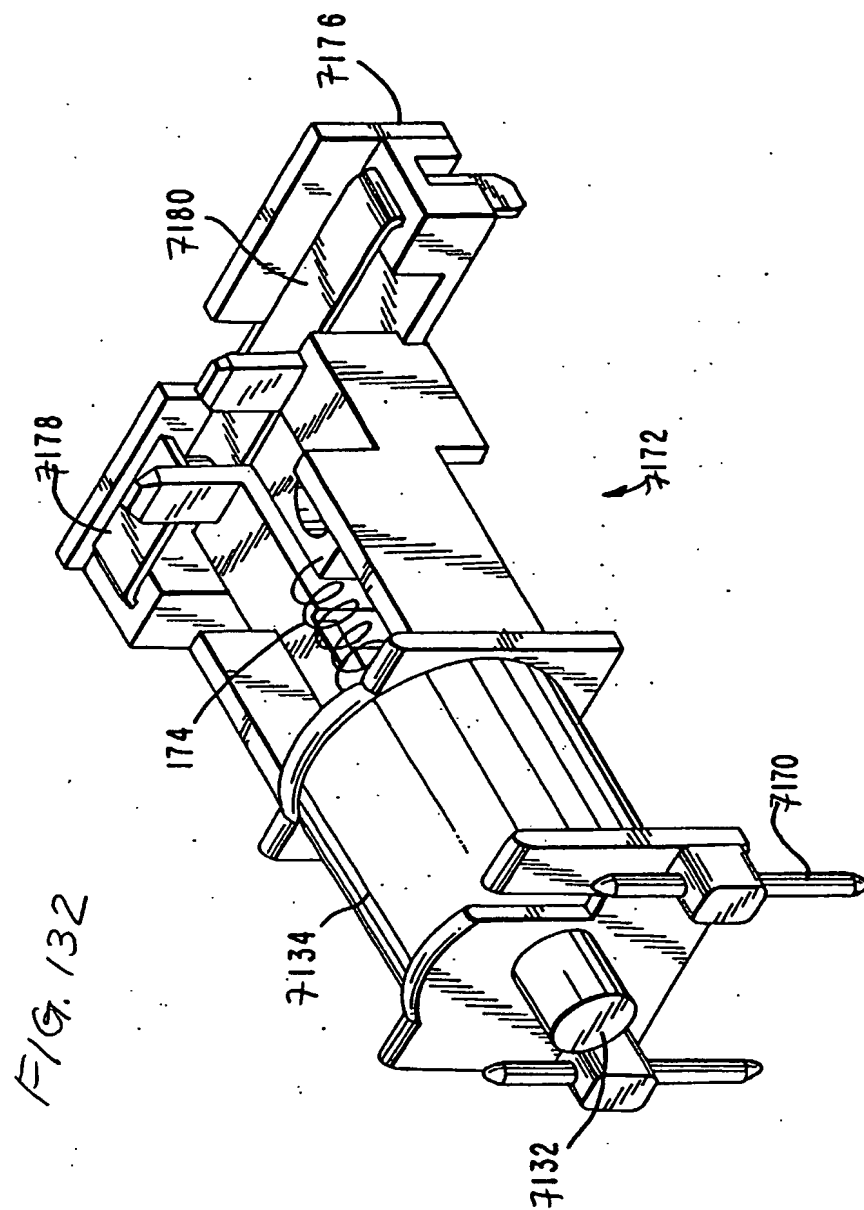
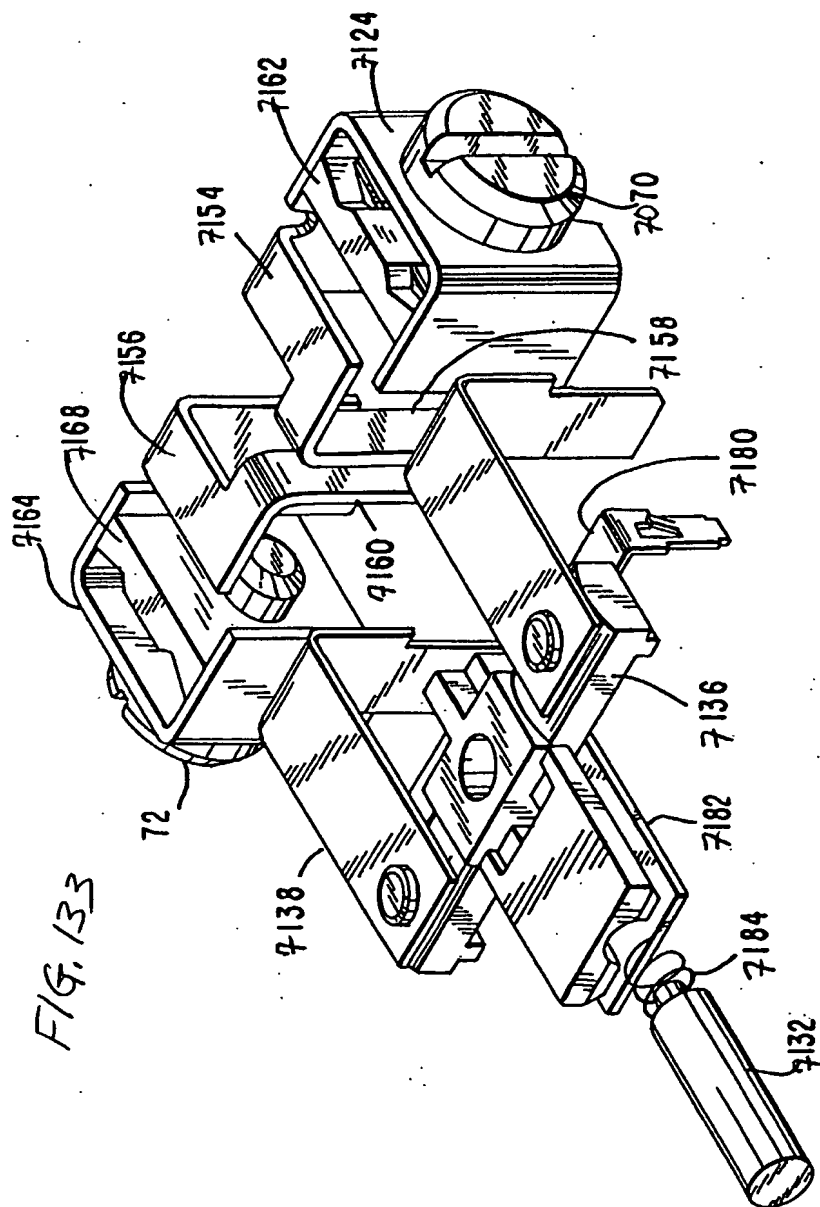


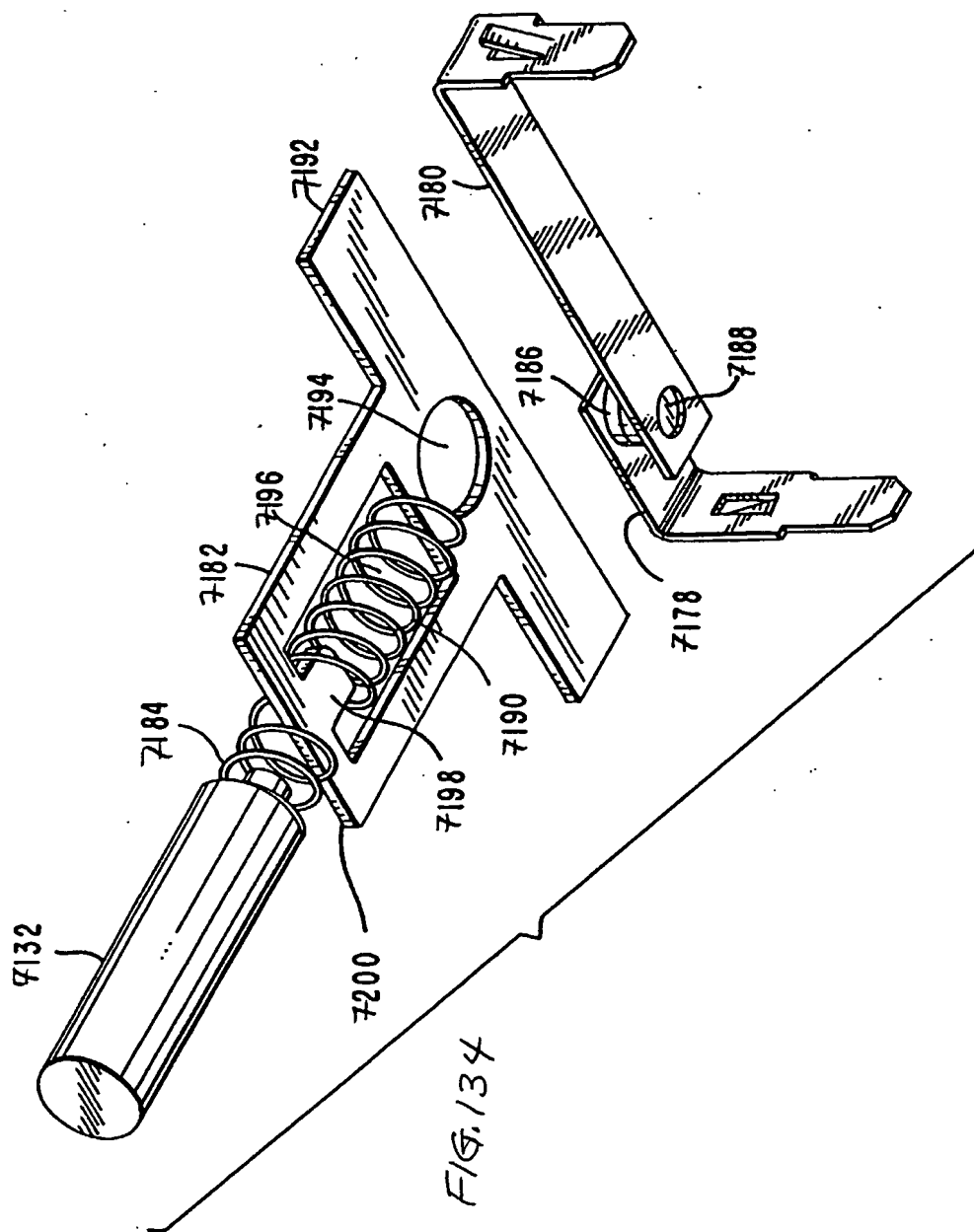
FIG. 129











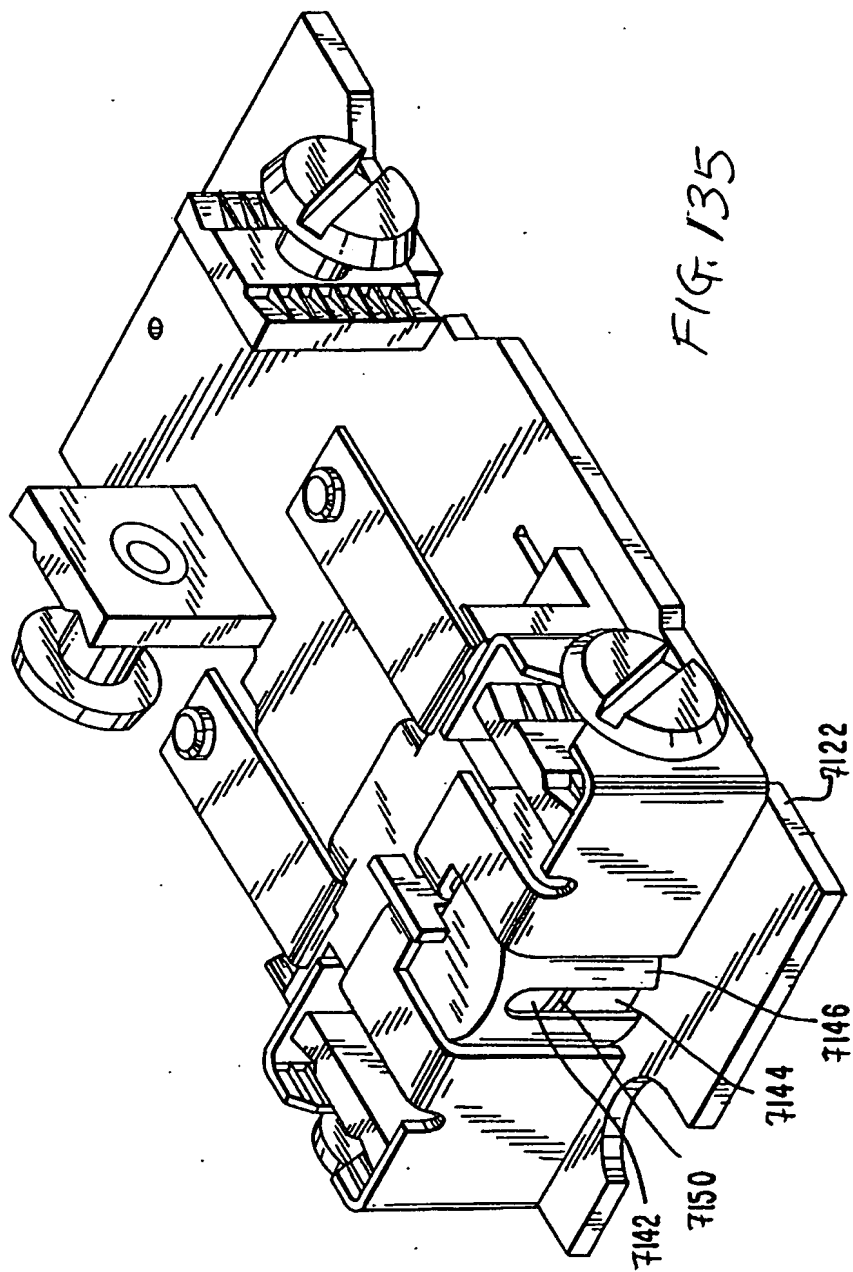


FIG. 136

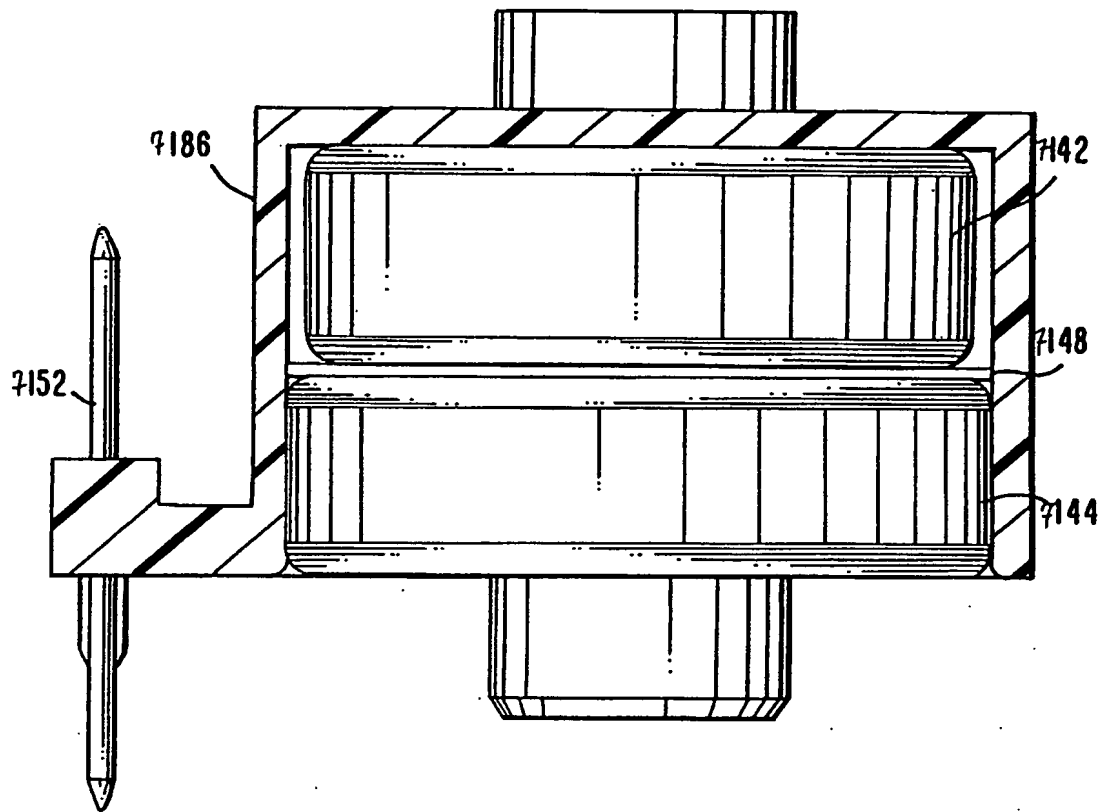
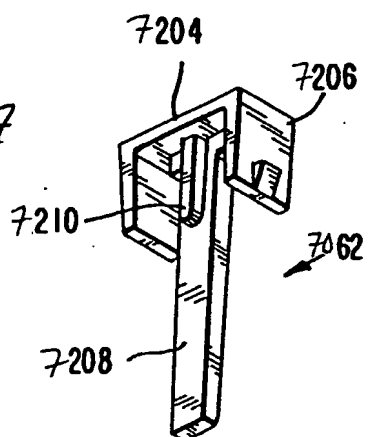


FIG. 137



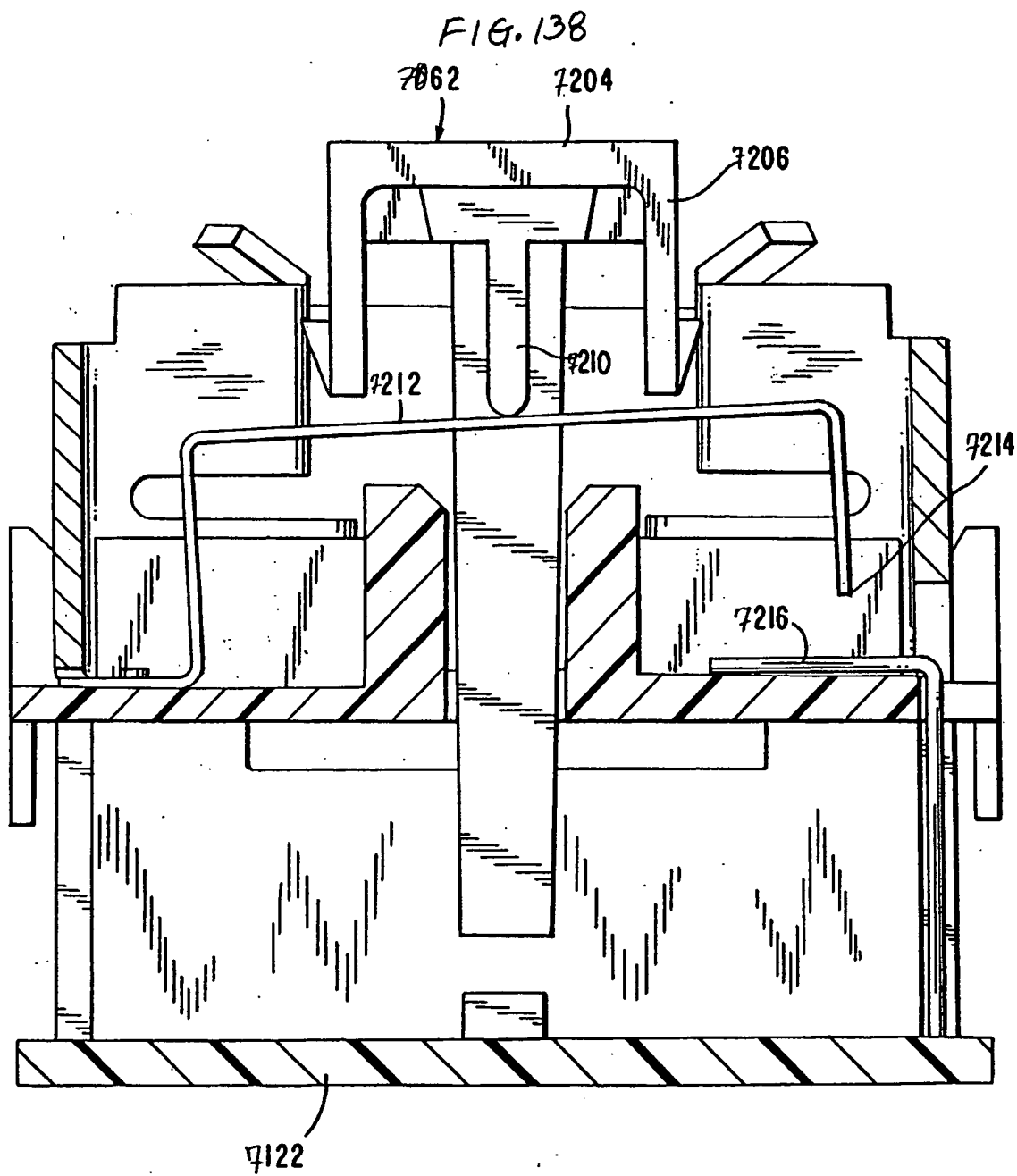
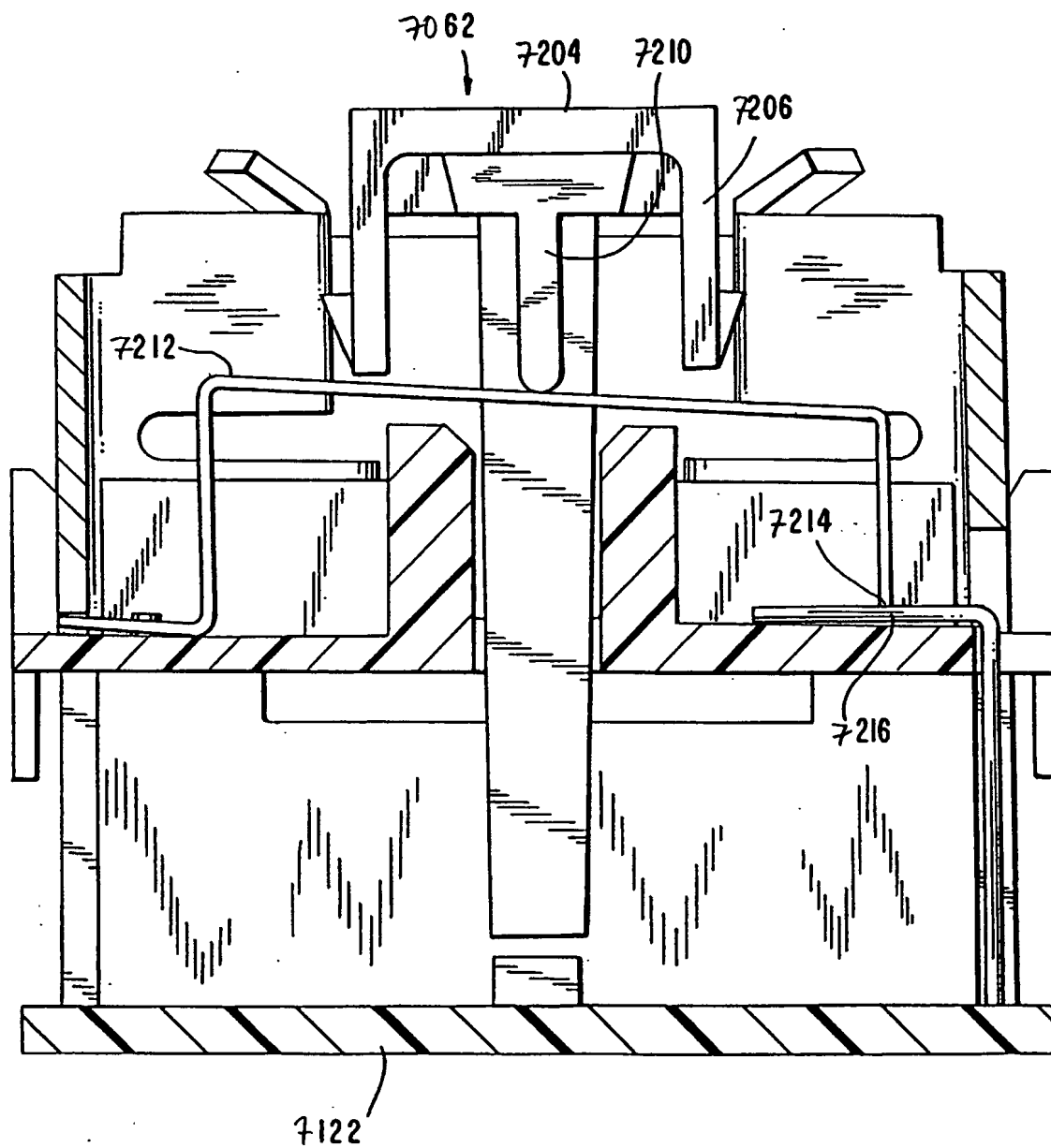


FIG. 139



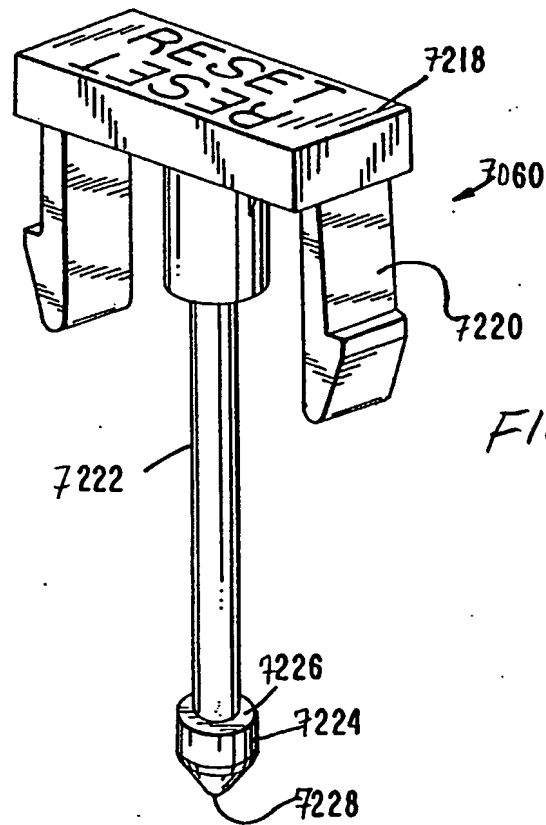
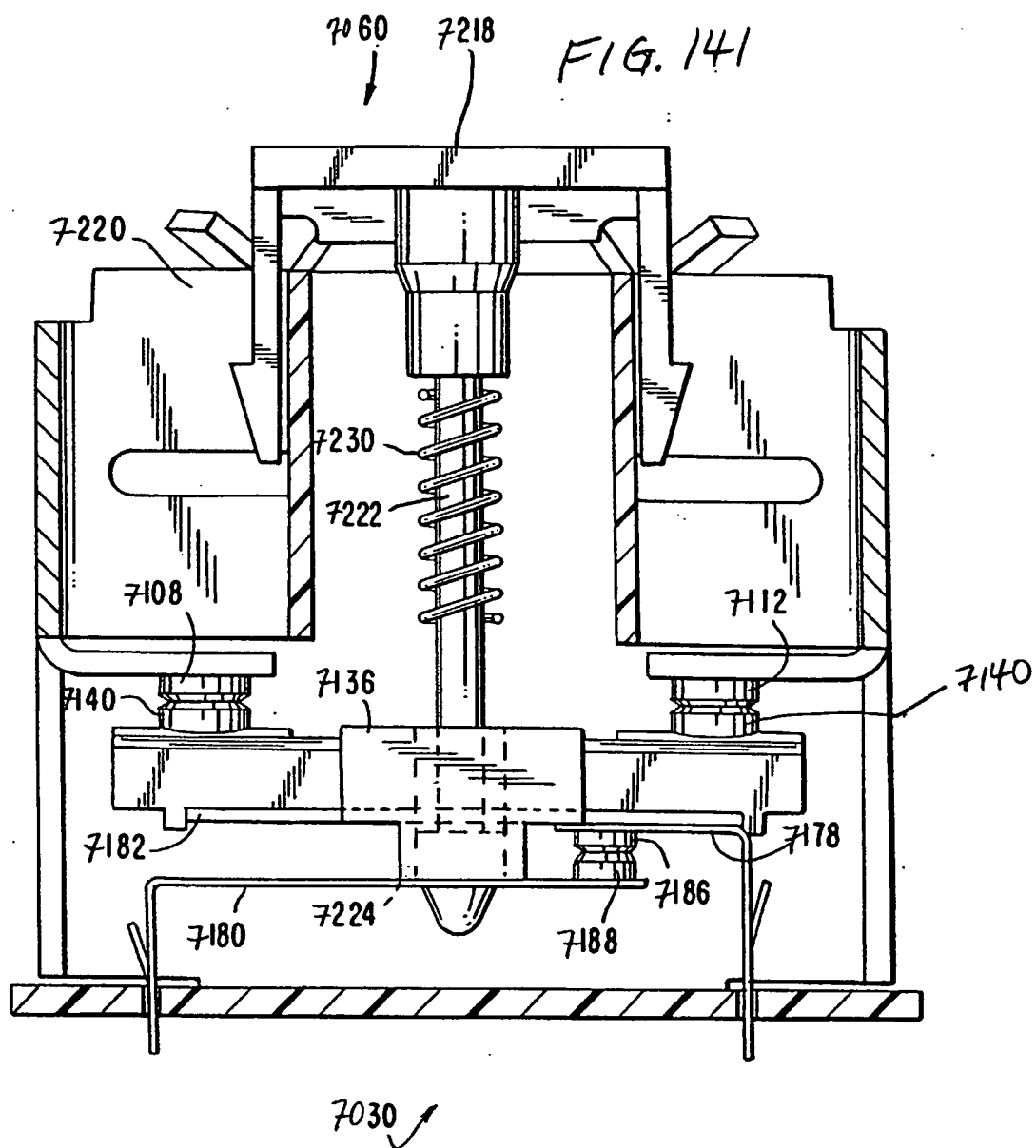


FIG. 140

MODE	LED INDICATOR			PIEZO BEEPER
	GREEN	RED	AMBER	
SUPERVISORY	SLOW	NA	NA	OFF
25 DAYS	FAST	NA	NA	OFF
30 DAYS	NA	NA	FAST	OFF
TRIP-EXTERNAL FAULT	NA	NA	FAST	ON
FAULT IN GFCI	NA	FAST	NA	ON
POWER ON RESET	NA	NA	FAST	OFF

FIG. 145



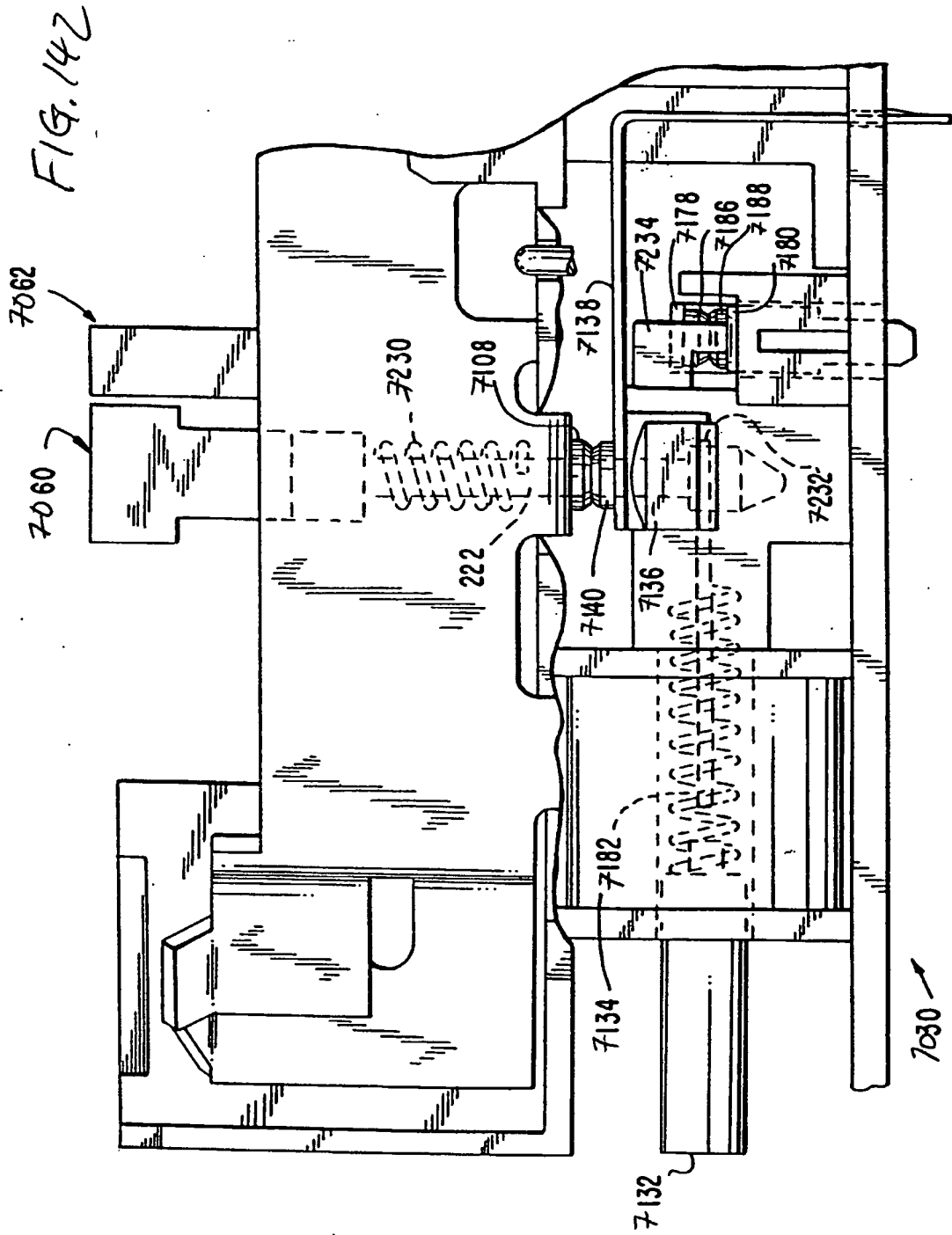
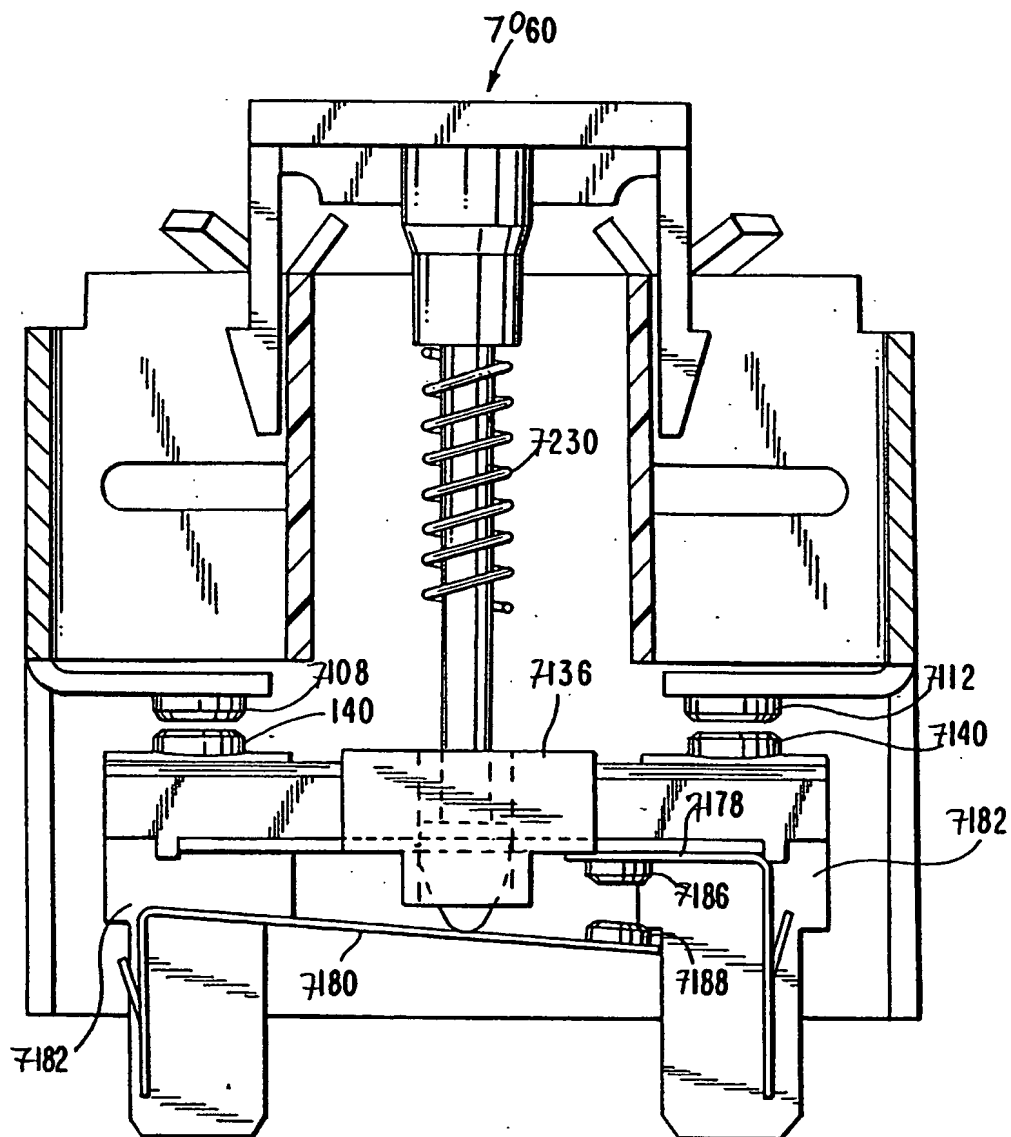
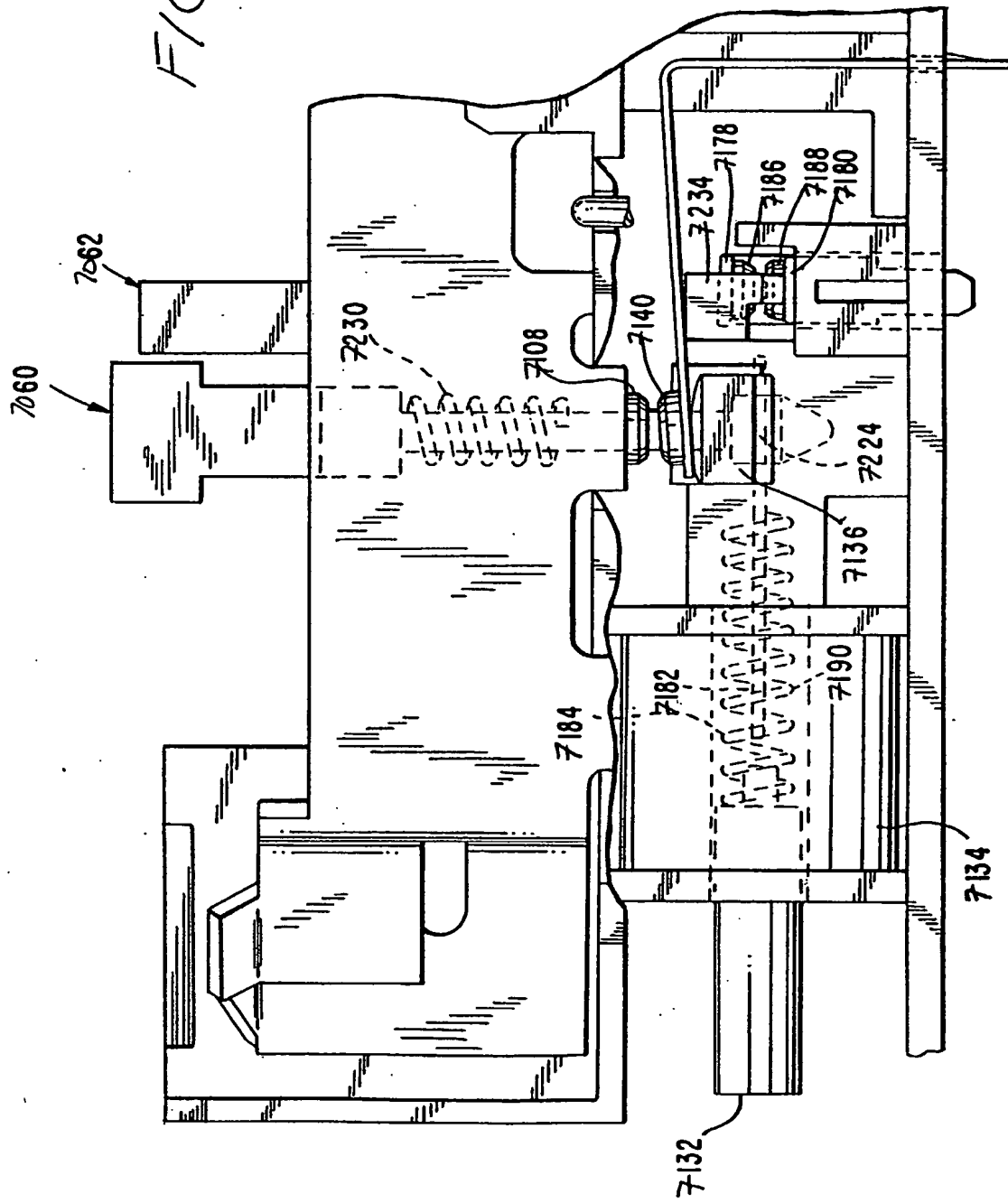


FIG. 143



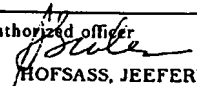
70.30 ↗

FIG. 144



INTERNATIONAL SEARCH REPORT

International application No.
PCT/US01/32562

A. CLASSIFICATION OF SUBJECT MATTER IPC(7) : H01H 73/00 US CL : 361/42 According to International Patent Classification (IPC) or to both national classification and IPC																				
B. FIELDS SEARCHED Minimum documentation searched (classification system followed by classification symbols) U.S. : 361/42, 43-50, 85, 87, 93-98; 335/18 ; 340/650 Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched Electronic data base consulted during the international search (name of data base and, where practicable, search terms used) EAST "GFCI" or ground fault circuit interrupter or resettable circuit interrupter																				
C. DOCUMENTS CONSIDERED TO BE RELEVANT																				
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.																		
A	US 5,594,398 A (MARCOU et al] 14 January 1997, figs. 1, 11, 30, col. 4, lines 7-9, col. 6, lines 5-10 and col. 10, line 67 to col. 11, line 17.	1-13, 34-41																		
Y	US 5,594,398 A (MARCOU et al] 14 January 1997, fig. 11, col. 2, lines 12-17 and col. 5, lines 46-61.	14-33 and 42-63																		
Y	US 5,875,087 A (SPENCER et al] 23 February 1999, figs. 1, 5, 8, col. 4, lines 51-64 and col. 6, lines 5-23.	14-33																		
<input checked="" type="checkbox"/> Further documents are listed in the continuation of Box C. <input type="checkbox"/> See patent family annex.																				
<table border="0"> <tr> <td>* Special categories of cited documents:</td> <td>"T"</td> <td>later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention</td> </tr> <tr> <td>"A" document defining the general state of the art which is not considered to be of particular relevance</td> <td>"X"</td> <td>document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone</td> </tr> <tr> <td>"E" earlier document published on or after the international filing date</td> <td>"Y"</td> <td>document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art</td> </tr> <tr> <td>"L" document which may throw doubt on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)</td> <td>"&"</td> <td>document member of the same patent family</td> </tr> <tr> <td>"O" document referring to an oral disclosure, use, exhibition or other means</td> <td></td> <td></td> </tr> <tr> <td>"P" document published prior to the international filing date but later than the priority date claimed</td> <td></td> <td></td> </tr> </table>			* Special categories of cited documents:	"T"	later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention	"A" document defining the general state of the art which is not considered to be of particular relevance	"X"	document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone	"E" earlier document published on or after the international filing date	"Y"	document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art	"L" document which may throw doubt on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	"&"	document member of the same patent family	"O" document referring to an oral disclosure, use, exhibition or other means			"P" document published prior to the international filing date but later than the priority date claimed		
* Special categories of cited documents:	"T"	later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention																		
"A" document defining the general state of the art which is not considered to be of particular relevance	"X"	document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone																		
"E" earlier document published on or after the international filing date	"Y"	document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art																		
"L" document which may throw doubt on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	"&"	document member of the same patent family																		
"O" document referring to an oral disclosure, use, exhibition or other means																				
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Date of the actual completion of the international search 05 JANUARY 2002		Date of mailing of the international search report 05 MAR 2002																		
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INTERNATIONAL SEARCH REPORT

International application No.
PCT/US01/32582

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 5,963,408 A (NEIGER et al) 05 October 1999, figs. 1, 6, col. 2, lines 32-37 and col. 5, lines 46-60.	42-63